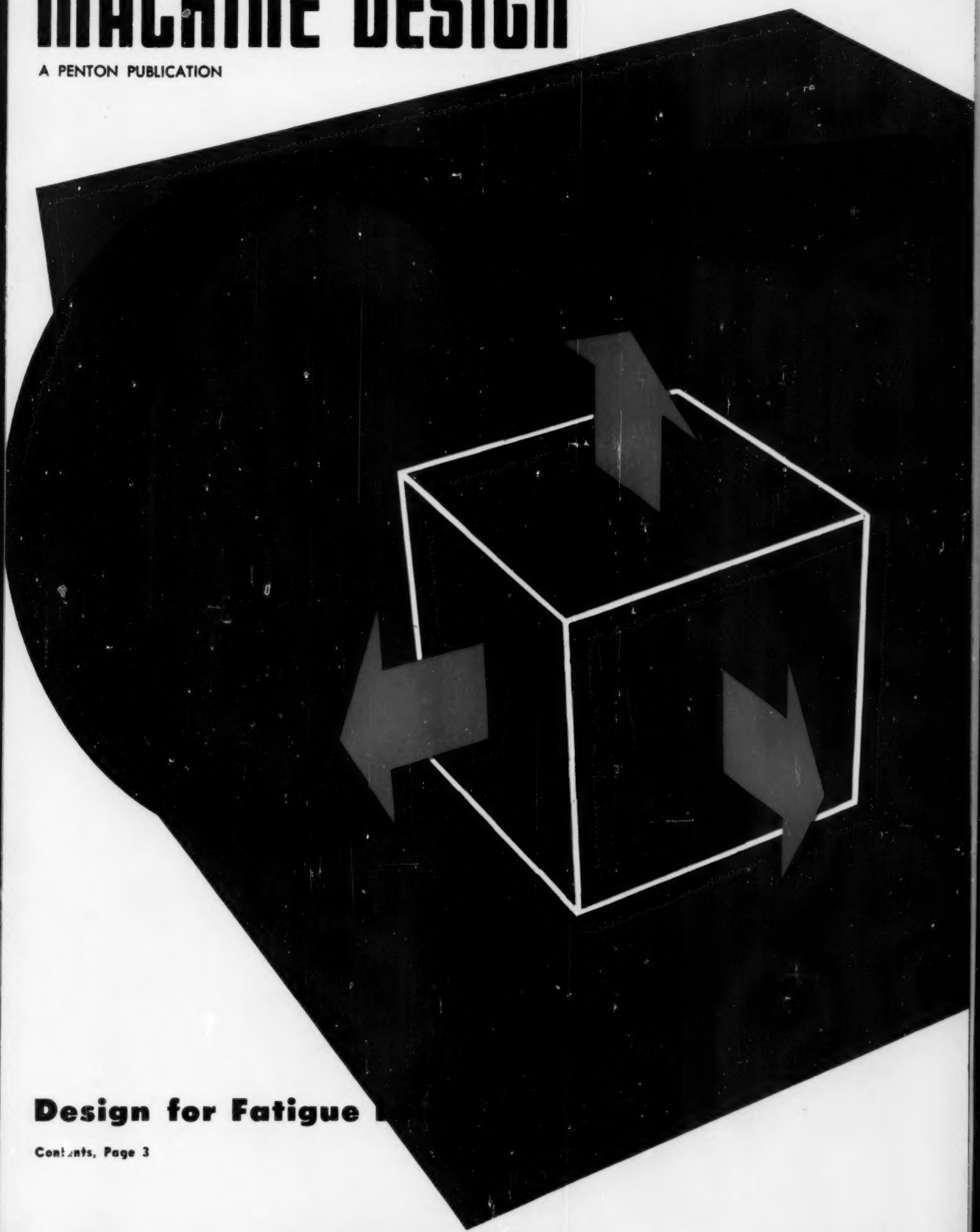
JANUARY 24, 1957
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Design for Fatigue

Contents, Page 3

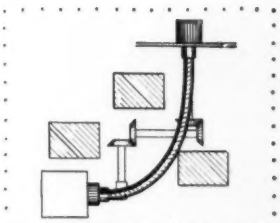
FARNSWORTH

S. S. White Flexible Shafts Eliminate Unnecessary Parts

One manufacturer used flexible shafts to replace 35 parts in a Hydraulic Power System . . . cut costs by 90%. Four flexible shafts replaced a 35-part remote-control system . . . simplified design . . . made assembly easier . . . eliminated alignment problems . . . improved performance!

This is only one of hundreds of remote control and power drive problems these quality flexible shafts are solving in every industry today. Can S.S. White flexible shafts help improve *your* product? Perhaps make it lighter in weight . . . cut production costs . . . eliminate unnecessary parts?

If you'd like to know more about flexible shafts, the advice of our engineers costs you nothing. Just write to



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Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

S. S. White

FIRST NAME IN FLEXIBLE SHAFTS

Useful data on how to select and apply flexible shafts! Write for Bulletin 5601.

Circle 401 on page 19

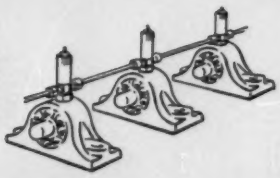
Design for

Automatic Lubrication From One Central Point

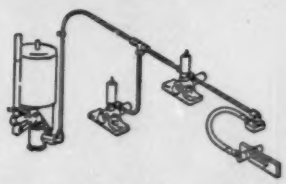
with an ALEMITE Accumatic® System

FASTER . . . FOOLPROOF . . . LESS COSTLY!

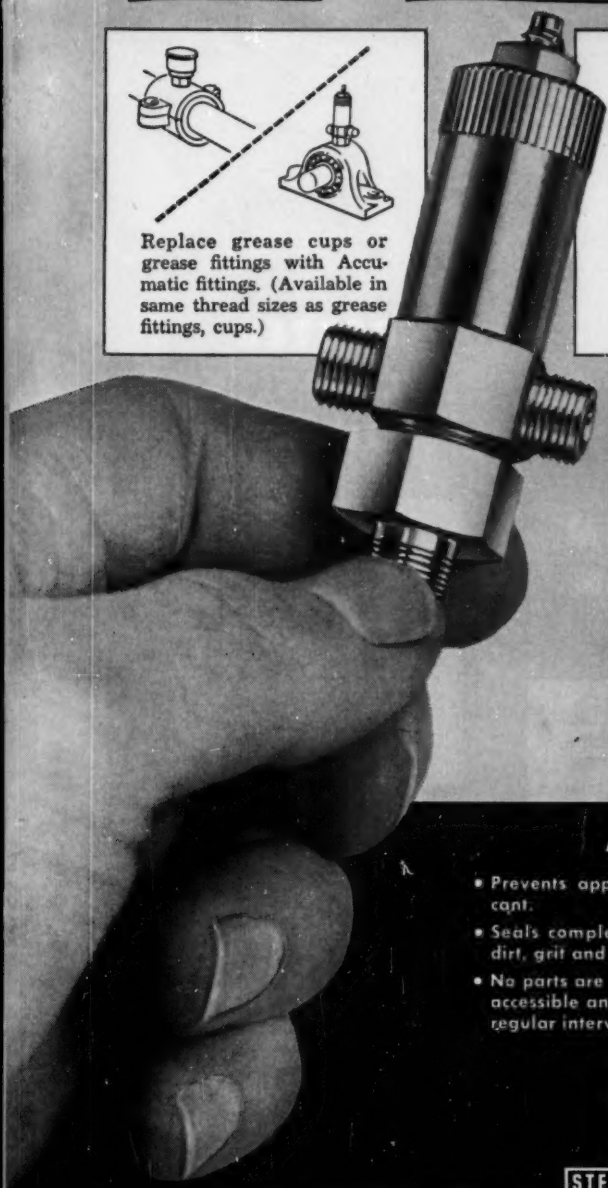
Replace grease cups or grease fittings with Accumatic fittings. (Available in same thread sizes as grease fittings, cups.)



Connect Accumatic fittings with copper tubing. (Alemite has tubing, clips and accessories for easy installation.)



Connect sliding, rotary or oscillating parts into tubing system. (Flexible hose and swivels for moving parts.)

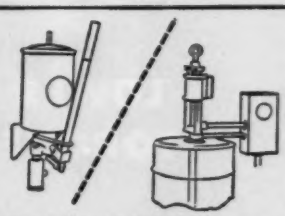


Type 1 Accumatic Valves

For fluid oil or light grease. In range of sizes, delivering from .005 to .100 cu. in. of lubricant. Various shapes: Tees, straight-thru, inserts, angles. Spring pressure provides gradual feed. Adjustable or fixed output. System serves up to 400 bearings. Manual or automatic operation available.

Factory-tested—field-proved!

Grueling field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—equal to *122 years of twice-a-day service!*



Provide central pump to supply lubricant to system. (Ordinary hand pump or fully automatic barrel pump.)

ALEMITE ACCUMATIC ADVANTAGES!

- Prevents application of wrong lubricant.
- Seals completely against damaging dirt, grit and water.
- No parts are neglected—lubricates inaccessible and dangerous bearings at regular intervals.
- Eliminates product spoilage due to over-lubrication.
- Eliminates point-by-point lubrication methods—services all bearings in one operation.
- Delivers *exact* amount of lubricant to bearing.

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Please send me my free copy of the complete Accumatic Catalog.

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Company _____

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Circle 404 on page 19

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REG. U. S. PAT. OFF.

A Division of STEWART-WARNER CORPORATION

STEWART SW WARNER

Check **THESE REASONS** ***and you'll see why you get better performance when you***

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LOWER TORQUE

Specially treated Sirvis-Conpor members available in C/R Oil Seals greatly reduce torsional drag, won't score shafts. They provide positive sealing over longer service life, are completely self-lubricating. Write for detailed information.

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

January 24, 1957
Volume 29—No. 2

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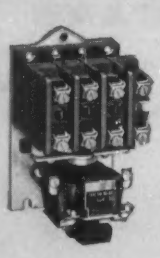
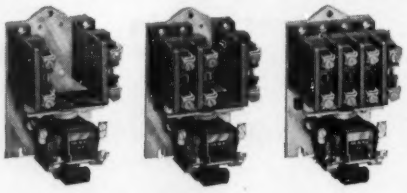
From 5 basic models you get 10 standard relays with the new CLARK Type "PM" Relay line

The 5 Basic Models

SECTIONAL POLE CONSTRUCTION—a new design concept for relays—provides units with 2 to 12 poles, with the greatest variety of combinations and pole arrangements available in an integrated 10-ampere line, and with a minimum of different parts to stock. Extra poles are available in kit form—assembled either normally open or closed. Coils and complete magnet assemblies are also available in kit form. Stocking of coils is simplified since one coil for a given voltage will handle any combination of 2, 3 or 4 poles normally open or closed, and for larger relays is correspondingly simple.

No. 5U-4
Basic
4-Pole

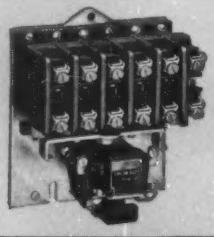


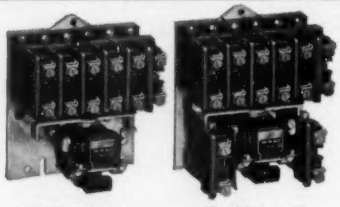


2-POLE 3-POLE 4-POLE

By removing one or two poles, the standard 4-pole unit becomes a 2 or 3-pole relay.

No. 5U-6
Basic
6-Pole

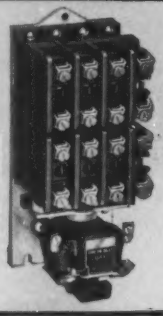


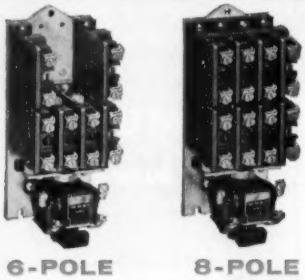


6-POLE 8-POLE

By adding 2 poles next to magnet, the standard 6-pole relay becomes an 8-pole unit—*the first 8-pole relay available for single deck wiring.*

No. 5UK-8
Basic
8-Pole

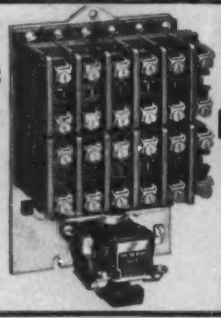


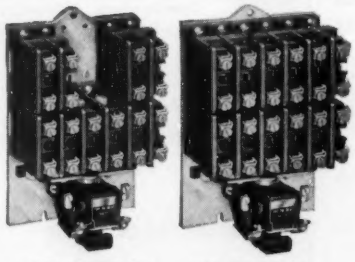


6-POLE Double-decked 8-POLE Double-decked

By removing 2 poles from the double-decked 8-pole relay, you get an alternate 6-pole of double-deck construction.

No. 5U-12
Basic
12-Pole

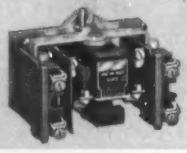




10-POLE 12-POLE

With 2 poles removed, the 12-pole unit becomes the standard 10-pole relay. Both have identical mounting dimensions with NEMA standard size 1 starters.

No. 5UK-2
2-Pole



2-POLE "SPACE SAVER"—a special purpose relay designed exclusively to meet small or unusual space requirements. Overall height less than 3 inches.

Write for 8-page illustrated Bulletin PL-7305 for complete information on this revolutionary new line of heavy-duty relays. Or contact your nearest Clark Distributor.

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Circle 406 on page 19

Engineering News Roundup

Multipurpose Farm Machine Automates Soil Conditioning

PORTLAND, ME.—Automated farming is extended by a new multipurpose machine which completely prepares and conditions the soil, plants seed and packs the earth in one operation. A prototype has completed a year of testing under actual farm conditions. The new machine, called Wonsover Model 96, was developed by the Norton Portland Corp. and will be manufactured by Todd Shipyards Corp. The Wonsover is considered comparable in significance to the reaper.

In operation, the 12-ton machine is towed by a tractor. A control panel on the tractor is attached to the Wonsover by an extension cord. Pushbuttons on the panel give finger-tip control of the machine functions.

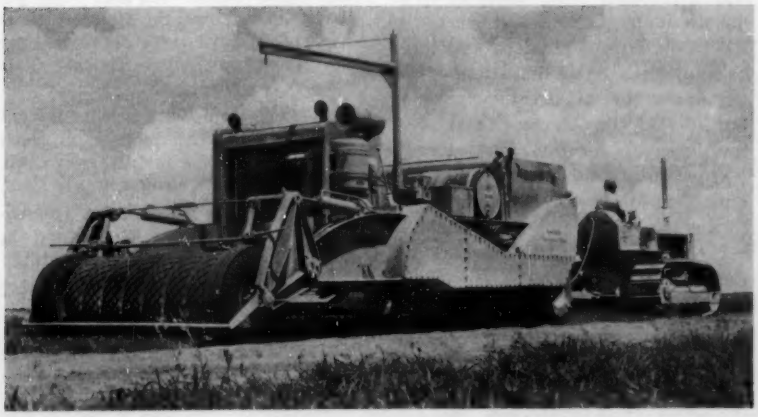
The Wonsover will prepare land in strips 8 ft wide. Depending upon soil conditions, it covers 2 to 5 acres an hour.

At the front of the Wonsover are bins and tanks from which fertilizer, lime, weed and pest killer are fed. In an attrition chamber behind them the operations of plowing and harrowing are reproduced. Depth of treatment to a maximum of 10 in. is adjustable by means of hydraulic cylinders which raise or lower the machine on its wheels. In the attrition chamber, liquid fertilizer or pest killer from two tanks can be added while the soil is in suspension.

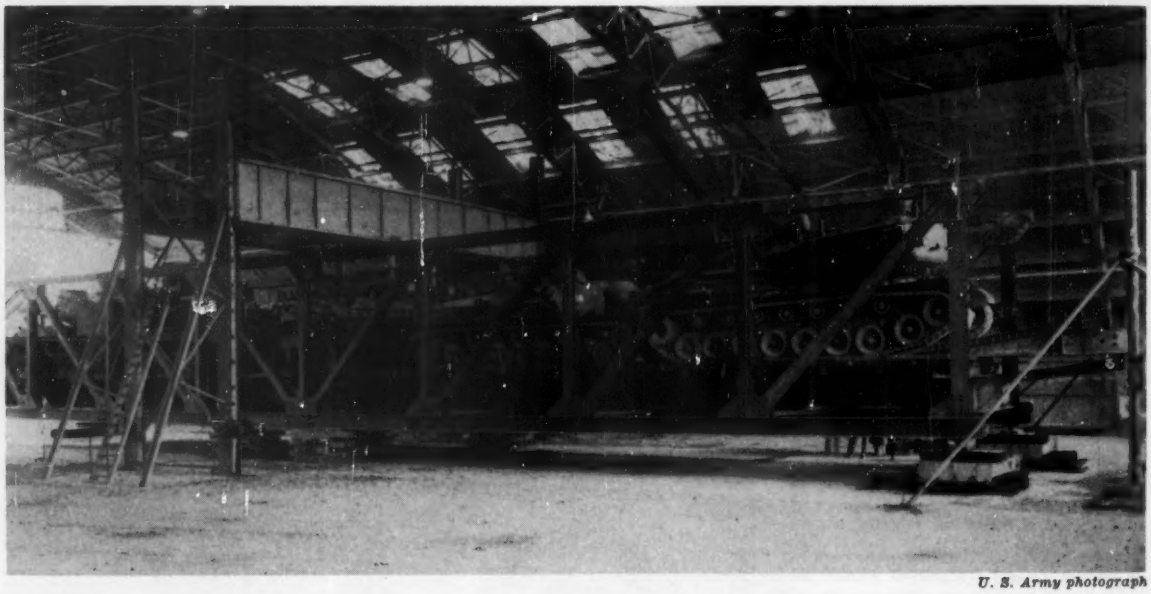
Following the attrition chamber is a revolving blade of hard rubber which smooths the conditioned soil and prevents the escape of soil moisture.

Any seeder a farmer may have can be adapted to the seeding bay to plant garden crops, legumes, seed grains or root vegetables. The de-

B-58 HUSTLER, in one of first official Air Force photos, heads toward its operating altitude of 50,000 ft. The Hustler was built by Convair, has four G-E J-79 turbojet engines with afterburners. The bomber is 95 ft long and has a wingspan of 55 ft. It carries a crew of three. The plane incorporates 16 major subsystems, including its own defense system, all virtually automatic. Hustler is the world's first supersonic bomber with the possible exception of a recent Russian plane of lighter weight and shorter range.



More produce per farm man-hour should result from the use of this new machine, called Wonsover. Simultaneously, it conditions soil and plants seed in strips 8 ft wide at the rate of 2 to 5 acres per hour. Operations of the Wonsover are controlled from a panel on the tractor.



U. S. Army photograph

BRIDGE TESTING MACHINE simulates military traffic in the development of new structures at the Corps of Engineers' Research and Development Laboratories. In the test shown, four medium tanks augment the machine and help distribute a load of 888,000 lb on an experimental railroad bridge 120 ft long with trusses 15 ft deep. The machine has two pairs of columns 45 ft apart which support girders 5 ft deep. The bottom girder flange carries four hydraulic rams each capable of 100 tons of force. Their positions on the flange can be changed to correspond to the actual tread of vehicles. Hydraulic pumps supply maximum safe pressure of 7000 psi to the rams. Electronic cells of 100-ton capacity measure applied loads, and electrical strain gages record the strain in structural members. Dynamic loads recorded by oscillograph equipment simulate moving traffic.

vice can also be adjusted to plant broadcast or in rows.

A subsoiler, installed as optional equipment, is used to improve the distribution of moisture. Remotely controlled, it can be adjusted to a depth of 25 in.

Seven adjustable-pressure wheels pack the soil over the seed. The tire treads leave a notched pattern to prevent erosion.

The final device at the back of the machine will apply spray to kill weeds or insects that might be blown onto the newly planted soil.

The ASME Medal for 1956 was presented to Harry F. Vickers at the Society's recent annual meeting. The award is for "distinguished service in engineering and science." Mr. Vickers, president of Sperry Rand Corp. and founder of Vickers Inc., was cited in particular for "pioneering in industrial oil hydraulics and for notable accomplishments in business leadership."

Society Queries Reveal Need For More Gray Iron Data

CLEVELAND, O.—Engineers want better distribution of up-to-date information on the design of castings and the mechanical and physical properties of gray iron. This was concluded from returns to a questionnaire circulated recently by Gray Iron Founders' Society. The answers to 11 questions gave engineers the opportunity to elaborate on the theme "How can foundries aid product engineers?"

One question was a multipart quiz. You might check your own information on gray iron castings before turning to the answers on Page 25. This is what the Society asked:

1. Given a properly cleaned gray iron casting, would you say that aging it outdoors several months improves machinability or not?

2. Gray irons are available under standard specifications with tensile strengths of from 20,000 to_____ psi.

3. Ductile irons may be purchased under standard specifications with strengths as high as_____psi.

4. What would you say is the maximum temperature at which a high strength gray iron casting can maintain its load carrying ability?

5. When used as crankshafts, gray iron castings require considerably less machining than steel forgings. But what about weights? To get the needed strength, finished castings would have to be approximately how much heavier than finished forgings?

6. The term "semisteel" is (1) actually steel, (2) there is no such thing, (3) high-strength gray iron, (4) low-strength gray iron?

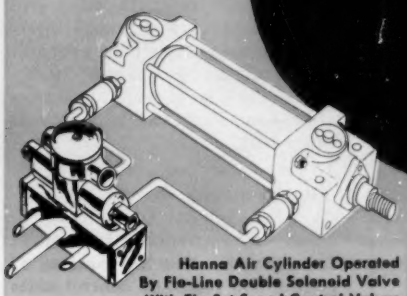
7. How close a tolerance (dimensional accuracy) can be secured on a shell molded gray iron casting?

Front Cover

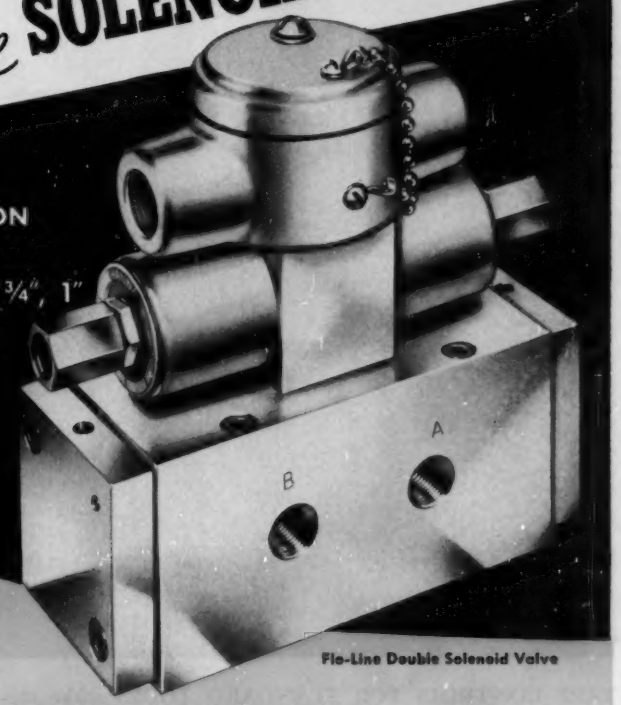
An endurance stress symbol and the conventional cube for triaxial stresses are combined by artist George Farnsworth to express designing for maximum fatigue strength. Featured series is by Joe Marin starting on Page 88.

HANNA *Flo-Line* SOLENOID VALVES

4-WAY VALVES
FOR AIR OPERATION
UP TO 150 PSI
SIZES: ¼", ⅜", ½" ¾", 1"



Hanna Air Cylinder Operated By Flo-Line Double Solenoid Valve With Flo-Set Speed Control Valves



Flo-Line Double Solenoid Valve

Hanna has designed and built new and unusual features in their Flo-Line Solenoid Valves . . . features that result in economy, more versatile operation and safety. Here are some of them:

- **Bubble Tight Spool** positively sealed by "O" rings.
- **Dust-Tight, Splash-Proof Design** to seal out dirt and moisture, and assure trouble free performance.
- **Few Moving Parts** for longer valve life.
- **Full Pipe Capacity** for all internal passages.
- **Wide Range of Temperatures and Pressures** —40° F. to 125° F.; 20 to 150 psi air. Options permit air pressure to 250 psi and even vacuum!
- **Enclosed Solenoid Coils** for safe operation.
- **AC or DC Service,** coils are available for most voltages and frequencies.
- **Meets JIC Recommendations** in all respects when ordered with optional manual over-ride.
- **Side or Manifold Porting** for easy installation and convenient piping.
- **Choice of Spools** permits selection of a standard valve for most applications.
- **Manual Over-ride,** an optional feature, allows equipment to be tested before final electrical installations are made and provides a means of operating the valve in case of electrical failure.
- **Junction Box** for ease in making electrical connections.
- **Modern Clean Cut Appearance**

You'll surely want the complete details given in the new Hanna Flo-Line Catalog No. 261A. See your classified telephone directory or Thomas' Register for the name of your nearest Hanna Representative—or write us direct.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT • CYLINDERS AND VALVES

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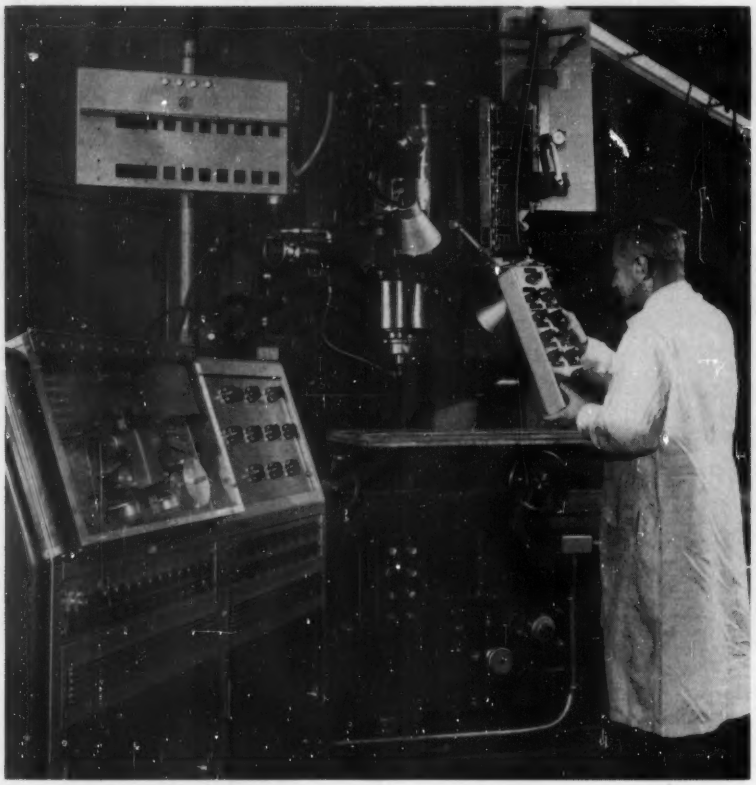
Circle 407 on page 19



TAPE CONTROLS FOR STANDARD TOOLS make this conventional milling machine fully automatic. Developed by Autonetics division of North American Aviation and called Numill, the controls include a display panel (upper left), a control pendant used by the operator, measuring gages, and a tape-reader console (lower left). Magnetic tape which carries directions for machine motions also flashes information to the operator from the panel. North American uses the controls to perform drilling, scribing, and contour-milling operations on parts defined in two dimensions. Tape data is converted into control pulses at 800 pulses per second. Each pulse causes 0.0005-in. straight-line machine motion. Directions for a representative part take 12 in. of tape.

Powder Parts Now Have Properties of Wrought Metal

NEW YORK, N. Y.—A new metal powder technique, developed at Sintercast Corp. of America, provides varied compositions tailored to specific requirements, in shapes typically associated with wrought products. Known as "Sinterwrought," the new process is said to eliminate many of the disadvantages of conventional powder and casting methods.

Sinterwrought products are claimed to have greater strength and ductility than conventional powdered metal products. Close control of composition of end items and the ability to obtain uniform dispersions of critical ingredients are also features of the process. Original ingredients of the powder mixture may be partially or totally insoluble in each other.

Typical products are aluminum strip and foil made from metal powder containing a uniform and accurate distribution of a small amount of an element needed in atomic energy reactors. The strip has the density, elongation and mechanical strength of conventional rolled aluminum foil.

Other metals handled by the Sinterwrought method include copper, nickel, cobalt, carbon steel,

Topics

Gyroscope testing — with gyroscopes—will be accomplished in carrier-based aircraft with a special turntable under development by the air arm division of Westinghouse Electric Corp. Gyroscopes to be tested are mounted on the turntable, which is gyroscopically controlled to keep it independent of ship action. Maximum error in measurement is 1/170 of a degree per second.

• • •

Nike B, a more advanced and deadly version of the present Nike I, is to be capable of destroying entire close formations of aircraft. Its range of about 75 miles will equal that of a short-range interceptor plane. Due to be ready in two years, the Nike B missiles can be installed in present Nike sites after some modification of ground equipment.

• • •

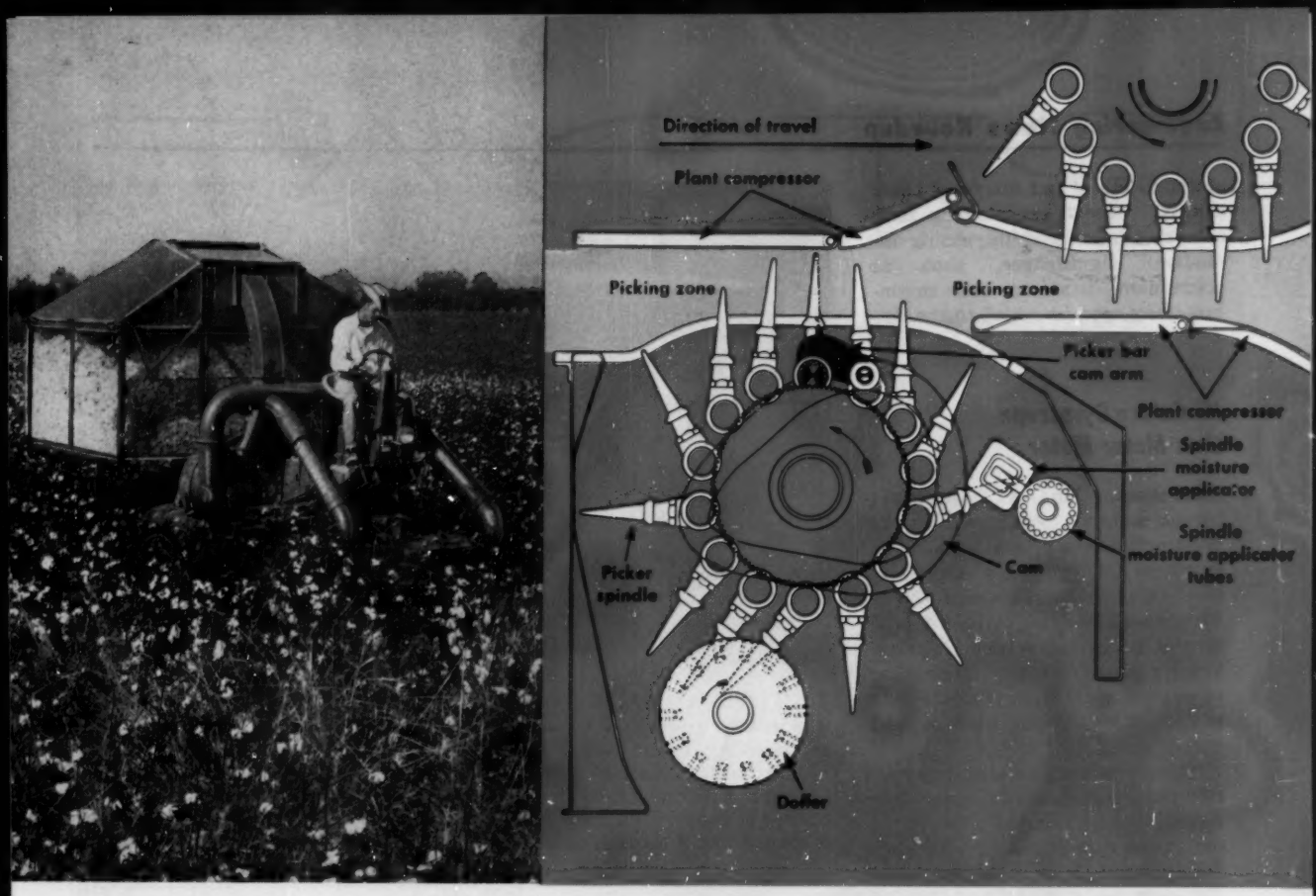
Building-block kit for automating a small plant has been introduced by Airborne Instrument Laboratories. The kit contains 57 gaging and feedback control units for machine tools.

• • •

No parking on the other fellow's nickel will be possible where a new Traffic Master meter is installed. This money-mad device registers "Expired" and waves its red flag as soon as an automobile leaves the parking spot, regardless of prepaid time not used. A light-sensitive photoelectric cell is sunk in the pavement about 30 in. from the curb and wired to a battery-operated switch in the meter. An auto parked over the cell and a coin placed in the meter close the circuit. When the car leaves, light strikes the cell, the switch is thrown and the next motorist is foiled.

• • •

New atomic theory, based on lowering instead of raising the temperature of atoms, has been advanced by Navy Scientist Robert Leon Carroll. Dr. Carroll's theory states that as an atom gets colder it becomes less active and electrons gravitate toward the nucleus at increasing speeds. He believes that if the atom is made cold enough, the electrons will plunge into the nucleus, releasing its entire energy. Air Force scientists will conduct tests on the Carroll theory.



How angular power transmission makes still another improved design practical

This cotton picking machine is just one of many, many products improved and made more practical through the flexibility of angular power transmission.

Using the angle of transmission shown at right, the makers of the machine can put a whole row of spindles on a bar and drive them with a single source. The spindles pluck bolls gently from the cotton plant and deliver them unmarred to a collecting basket.

Besides this flexibility, bevel gear transmissions usually weigh less, cost less, and carry heavier loads.

Our engineers are ready at all times to help you work out applications for bevel and hypoid gears.

They can discuss such items as mountings and lubrication. They can produce and test prototypes of your drives.

Finally, they can advise you on the proper machinery to use to produce top quality gears in large quantities at low costs.

Please write whenever you have an application in mind.

Meanwhile, you'll find these Gleason Technical Handbooks helpful:

20° straight bevel gear system
Spiral bevel gear system
Zerol® bevel system

The cotton picking machine shown above, uses 420 of these tapered spindles in its picking drum (diagram). The machine slashes picking costs by as much as 60%.

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Builders of bevel gear machinery for over 90 years

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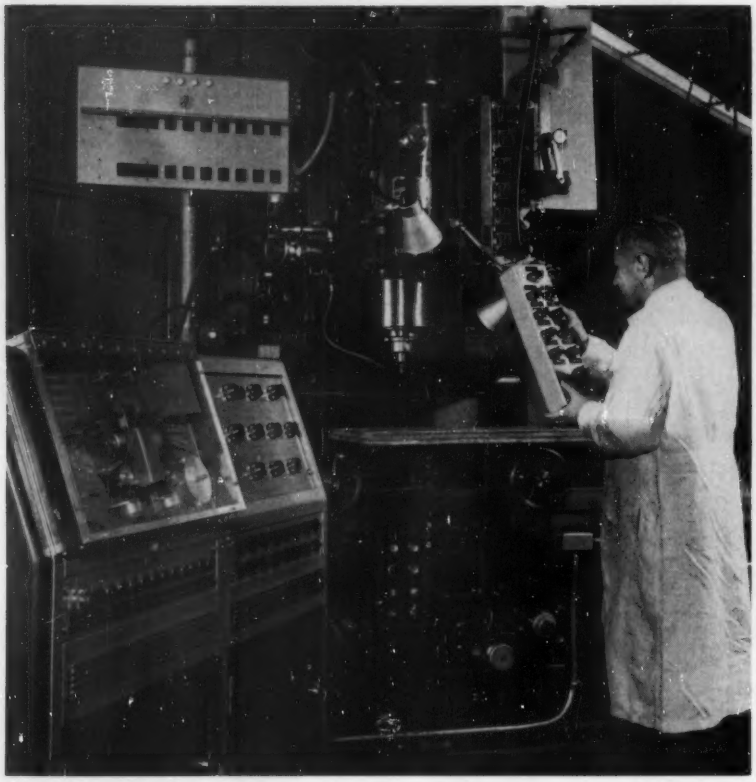

TAPE CONTROLS FOR STANDARD TOOLS make this conventional milling machine fully automatic. Developed by Autonetics division of North American Aviation and called Numill, the controls include a display panel (upper left), a control pendant used by the operator, measuring gages, and a tape-reader console (lower left). Magnetic tape which carries directions for machine motions also flashes information to the operator from the panel. North American uses the controls to perform drilling, scribing, and contour-milling operations on parts defined in two dimensions. Tape data is converted into control pulses at 800 pulses per second. Each pulse causes 0.0005-in. straight-line machine motion. Directions for a representative part take 12 in. of tape.

Powder Parts Now Have Properties of Wrought Metal

NEW YORK, N. Y.—A new metal powder technique, developed at Sintercast Corp. of America, provides varied compositions tailored to specific requirements, in shapes typically associated with wrought products. Known as "Sinterwrought," the new process is said to eliminate many of the disadvantages of conventional powder and casting methods.

Sinterwrought products are claimed to have greater strength and ductility than conventional powdered metal products. Close control of composition of end items and the ability to obtain uniform dispersions of critical ingredients are also features of the process. Original ingredients of the powder mixture may be partially or totally insoluble in each other.

Typical products are aluminum strip and foil made from metal powder containing a uniform and accurate distribution of a small amount of an element needed in atomic energy reactors. The strip has the density, elongation and mechanical strength of conventional rolled aluminum foil.

Other metals handled by the Sinterwrought method include copper, nickel, cobalt, carbon steel,

Topics

Gyroscope testing — with gyroscopes—will be accomplished in carrier-based aircraft with a special turntable under development by the air arm division of Westinghouse Electric Corp. Gyroscopes to be tested are mounted on the turntable, which is gyroscopically controlled to keep it independent of ship action. Maximum error in measurement is 1/170 of a degree per second.

• • •

Nike B, a more advanced and deadly version of the present Nike I, is to be capable of destroying entire close formations of aircraft. Its range of about 75 miles will equal that of a short-range interceptor plane. Due to be ready in two years, the Nike B missiles can be installed in present Nike sites after some modification of ground equipment.

• • •

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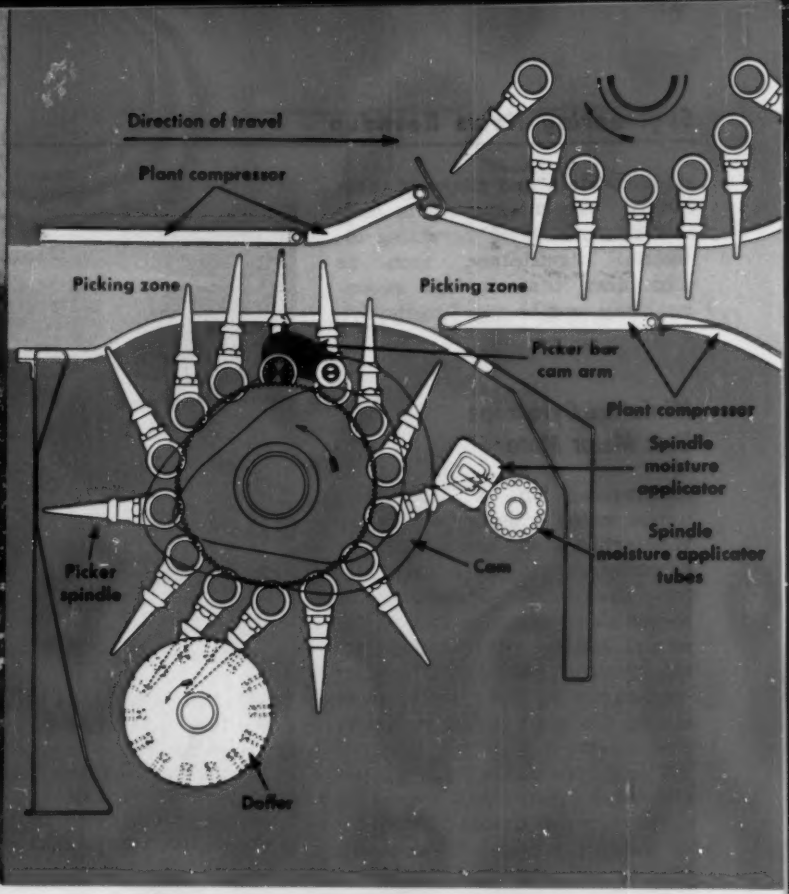

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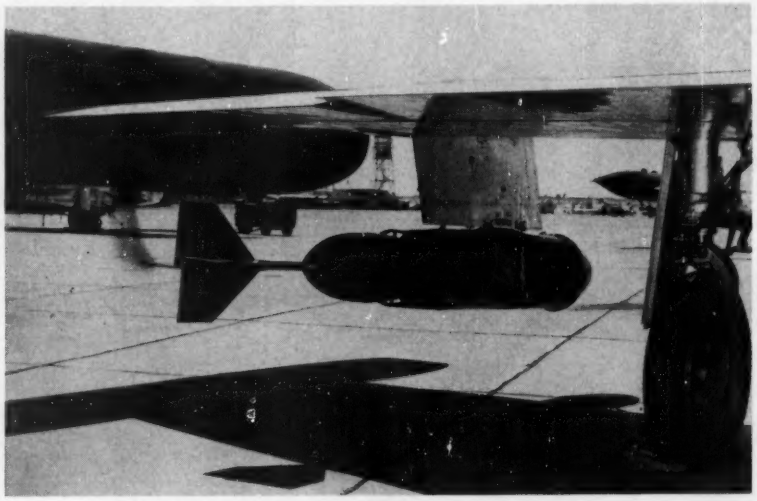
stainless steel, and alloys of these metals. Recent experiments indicate that metals of increasing industrial significance, such as columbium, titanium and zirconium, may soon be added to the list.

Miniature Gyroscope Uses Meter Motor

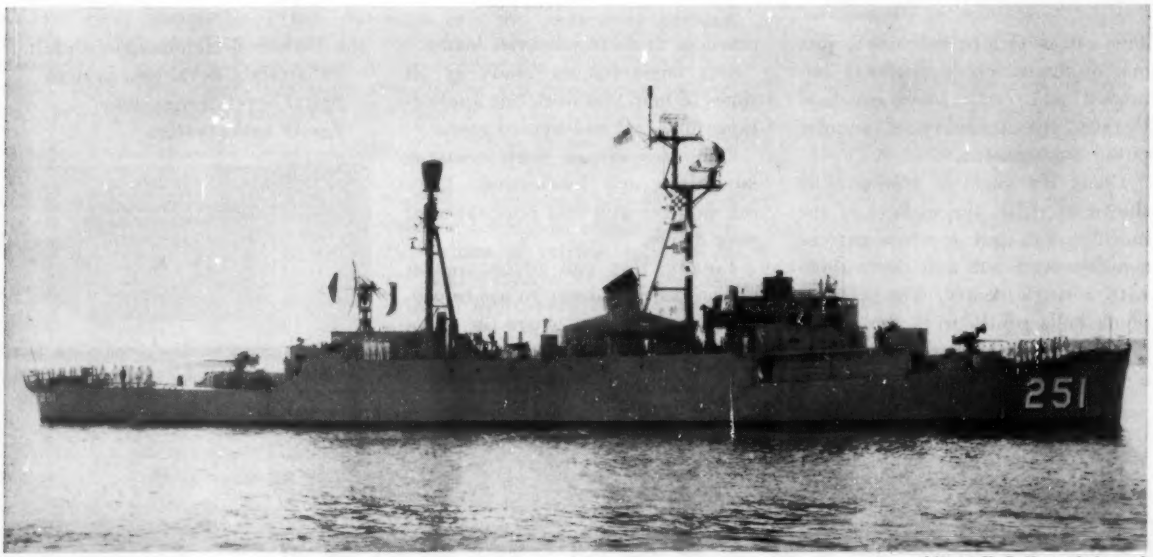
BALTIMORE, MD.—A d'Arsonval torque motor is being used by the Westinghouse air arm division in a miniature gyroscope especially for fire-control systems. The torque motor is one of four fundamental components that make up the gyroscope assembly. The other components are the gyroscope spin motor, the position detector, and the damper.

This gyroscope is a single-degree-of-freedom instrument employing a fully-floated gimbal. By virtue of damping provided by a viscous flotation oil, it may be employed not only as a rate gyro, but as an integrating gyro.

When the gyro is subjected to a rotation, the spin motor produces a torque proportional to the rate of rotation, causing the gimbal to rotate relative to the gyro case. This motion is detected by the position detector. By means of a feed-back amplifier, a current is delivered to the torque motor. The torque motor generates the restraint necessary to balance precession torque. The current fed to the torque motor is proportional to angular rate. The same current



TROLLING AT MACH 1.0 is the mission of this new tow target installed on a Northrop Scorpion F-89 interceptor. The fiber glass, torpedo-shaped target spins on cable 5 miles behind the tow plane. The stranded cable, made by American Chain and Cable Co., is 3/64-in. in diameter, has a breaking strength of 375 lb. The target is 20 in. in diameter, 10 ft long, weighs 15 lb. Spinning, caused by canted fins, assures good register on radar. The target is shaped like a torpedo to minimize drag and shatters when hit.



Official U. S. Navy photograph

RADAR PICKET SHIP, *USS Camp,* is representative of destroyer escorts being converted to scan the sky at sea. Before mid-1957, 36 picket ships will join the active fleet. Each ship will carry air-search radar, height finder, sea-search radar, antiaircraft and antisubmarine weapons. The ships will co-ordinate their operations with land-based stations nearest their assigned positions at sea and help comprise the offshore warning service.

FACTS

about

NEW DEPARTURE BALL BEARINGS

NINE REASONS WHY DISC PLOW BALL BEARINGS MEAN *SAVINGS*

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1. New Departure disc plow ball bearings require no adjustment for wear or preloading —eliminate threaded spindles, nuts, and washers.
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4. Assembly is simple, foolproof, lower cost.

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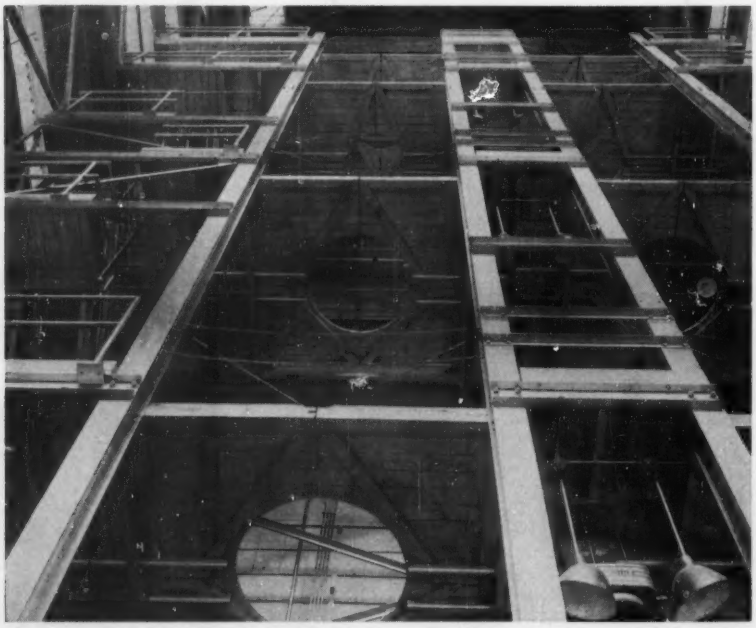

VANGUARD ASSEMBLY TOOL is this new building appended to plant No. 1 of the Martin Co., prime contractor for the three-stage rocket. The building is 29 ft wide, 35 ft long, 97 ft tall. Two Vanguards, 72 ft high, can be assembled inside at the same time. The building will also be used for simulated static firing of the vehicle. Folding floor boards at working levels permit Vanguard to be removed intact. The building itself can be disassembled and erected elsewhere.

is a measure of the angular rate of change of angular position in space, and is the output of the rate gyro.

When employed as an integrating gyro, the damper provides the gimbal restraint, and the torque motor is then used to command the gyro. The output in this case is obtained from the position detector and is the time integral of the rate of change of angular position.

Of particular interest is the concentric construction of the torque motor, designed for ease of assembly. The rotor is a low-inertia, nonmagnetic coil form. A preformed, flat coil is fastened on the rotor so that all conductors lie on the surface of a cylinder. The working conductors also lie parallel to and at a constant radius from the rotor axis. Surrounding this movable coil is a stationary structure.

The stator consists of a permanent magnet mounted within a flux-return ring which surrounds the rotor. The magnet provides a constant flux field in which the rotor winding operates. At the same time, the motor provides high torque and also linear torque-to-input current characteristic typical of the d'Arsonval movement. The motor develops torques greater than 3000 dyne-cm without any signs of saturation or hysteresis.

Predicts Production Increase Will Shrink Factory Size

DETROIT, MICH.—Fifty years from now, factories will be smaller than today's giant plants, predicts Ralph E. Cross, executive vice president of the Cross Co.

"This will be possible because of the industrial use of atomic power and the development of greater manufacturing flexibility, coupled with higher productivity. It will be economically sound and physically possible to build goods better and faster with smaller plants," he said recently.

"Business now is placing a greater emphasis on forward planning and on the elimination of obsolescence. . . . . This forward planning and the introduction of new technology are generating new jobs with important regularity."

Mr. Cross believes the use of the "building block" principle of machine design and construction will increase, resulting in more automated assembly lines as industries change over to this new cost-reducing equipment which provides flexibility for part design changes. He also said that preventive maintenance programs will grow stronger and "designed-in" ease of maintenance will receive more attention from engineers.

Pay of Engineers Grows Faster Than Other Groups'

WASHINGTON, D.C. — Earnings of engineers and other professional employees were 8.6 per cent higher in 1956 than in 1955. This is reported in an American Management Association survey for the period May, 1955, to May, 1956. The survey covered 31,400 engineers, scientists and administrative employees in 49 different activities at five levels. In the corresponding period one year earlier, earnings increase had been 4.5 per cent.

The survey showed that the increase was higher for engineers than for any other group covered. Engineers with less than one year of experience reported a median salary of $5300 per year. Those with experience from one to three

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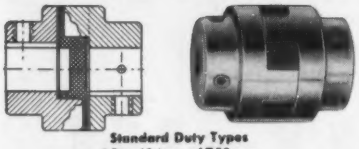
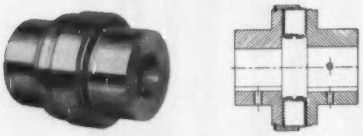
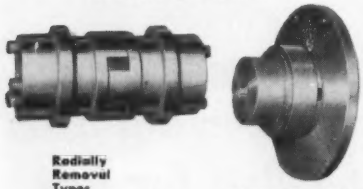


Standard Duty Types
.05 to 40 hp. at 1750 rpm.



Medium and Heavy Duty Types
2.6 to 810 hp. at 100 rpm.



Radially Removal Types
1.9 to 30 hp. at 100 rpm.—2 to 40 hp. at 1800 rpm.

Flange-Mounted Types
11 to 740 hp. at 900 rpm.

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Circle 411 on page 19

years earned a median $6500 per year.

In the highest salary ranges, earnings of different groups overlapped. It was noted that engineers are less likely to receive bonuses than the members of middle management.

Movement of the world's first electric wrist watch (right) is shown with movement of manually-wound watch. Created by the Hamilton Watch Co., the electric watch has one-third fewer parts and requires no winding or agitation. Large circle in top center of electric watch is a battery, called Energizer, which replaces the conventional mainspring.

First Electric Wrist Watch Has New Basic Timer Design

NEW YORK, N. Y.—The first basic change in watch construction in almost five centuries is featured in the Hamilton Watch Co.'s newest product, introduced Jan. 3. This is the world's first electric wrist watch to be made available to the public.

The radical design of the electric watch completely eliminates the mainspring, an integral part of portable time-keeping devices since it was invented in 1480 by Peter Henlein of Nuremberg, Germany. The new watch is the only one in existence which runs without winding or without periodic agitation, according to Hamilton.

The electric watch is driven by a battery which energizes a coil of fine wire fixed on a balance wheel. The electrical energy, through interaction with permanent magnetic fields, causes the balance wheel to oscillate. This oscillation is the mechanical motion which runs the watch.

A significant difference between the Hamilton motor and a conventional electric motor was pointed out by Dr. John Van Horn, Hamilton's director of research and development. The new power plant, he said, combined with a balance wheel, permits the flow of energy to be strictly controlled. As a result, the rotation of the hands can be held to an accuracy of more than 99.995 per cent.

The coil is made of wire five times finer than human hair. Tiny magnets used in the electrical system are made of platinum alloy. They are said to have the highest energy content of any magnet in the world today. The Hamilton electric watch is more nearly free from disturbance by stray magnetic fields than any other watch, ac-

(*Continued on Page* 22)

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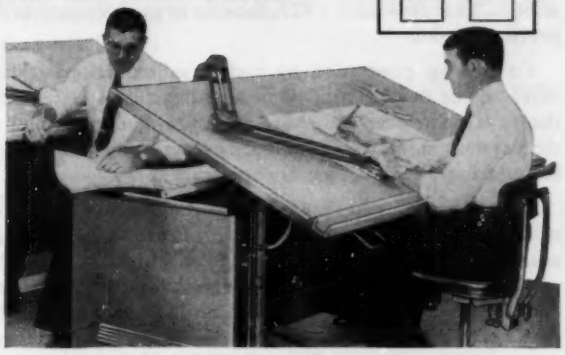

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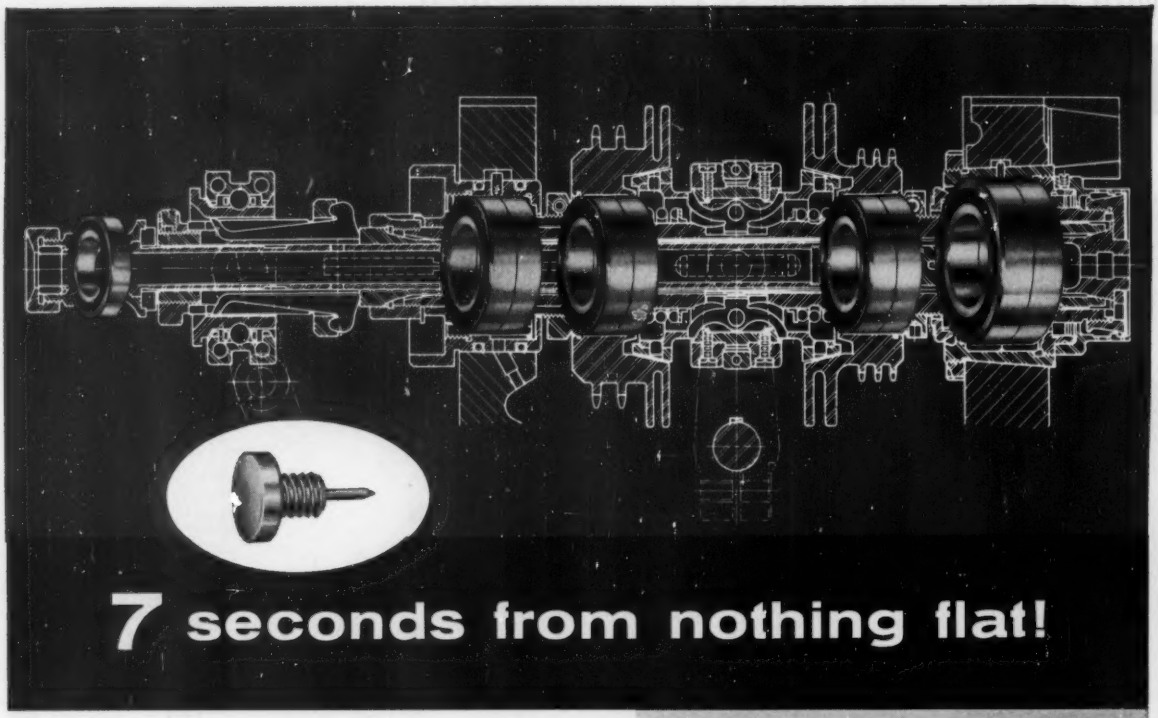


7 seconds from nothing flat!

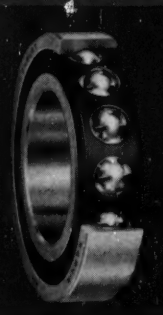
The brass part illustrated below the diagram is produced on the new 00 Brown & Sharpe Automatic Screw Machine in 7 seconds. That represents a 42% increase in production over the previous model.

To step up production by such a substantial percentage involved the development of new and exclusive features for the 00 machine over and above those proven so successful on the previous model. Included among them is the chain-driven, ball bearing spindle . . . see large diagram above.

In the selection and application of the bearings for the 00 spindle, Fafnir engineers worked with Brown & Sharpe engineers. The 208 speed combinations from a high of 7200 RPM to a low of 34 RPM, permitting high cutting efficiency on a wide range of materials, presented no ordinary problem for bearings. The bearing arrangement shown meets an exacting demand for maximum radial and axial rigidity to assure true balance and running accuracy of the spindle.

Could be there's no place in your machines for these super-precision bearings. But, whenever bearings are involved, there's certainly a place in your product planning for the Fafnir "attitude and aptitude" — a way of looking at bearing problems from the designer's viewpoint plus coming up with the right bearing to fit the need. Ask your Fafnir representative for details. The Fafnir Bearing Company, New Britain, Conn.

The New Brown & Sharpe No. 00 Automatic Screw Machine with Fafnir-equipped spindle.



Fafnir preloaded, angular-contact, super-precision ball bearings with composition or brass retainers are made to highest industry-approved tolerances. Single or duplex bearings like this are used widely on spindle applications.

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Circle 413 on page 19

MACHINE DESIGN
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Reader Information Service

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USE A YELLOW CARD
for More Information . . .

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

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NEW

KAYDON THIN SHELL NEEDLE BEARINGS

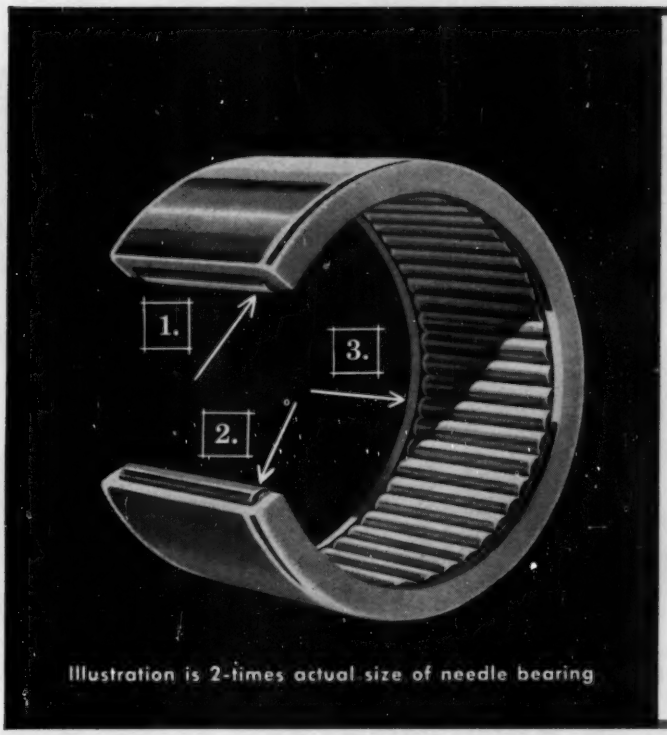
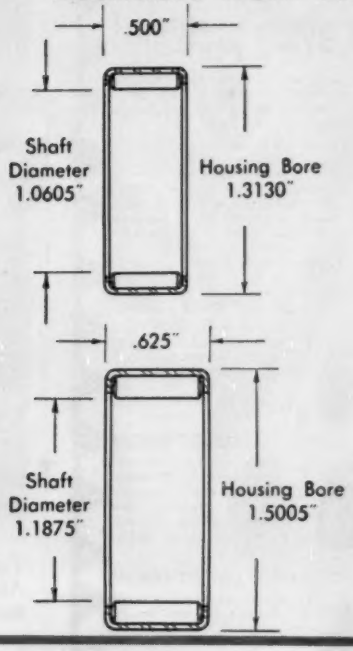


Illustration is 2-times actual size of needle bearing

Two standard sizes available from stock



You get these Kaydon design advantages:

1. Greater effective length needle rollers for MORE CAPACITY (41% on ½" width)... LONGER LIFE (2.8 times as much on ½" width) 2. Simplified construction that SAVES you money 3. Pre-packed lubrication that SAVES assembly time.

These new thin-shell bearings were developed with the co-operation of the FORD MOTOR COMPANY for use in FORD-O-MATIC and MERC-O-MATIC automatic transmissions

Kaydon's new thin-shell needle bearing gives more of everything — *more economy . . . more capacity . . . plus longer life* than any other comparable bearing. That's because of Kaydon's greater effective length of spherical end rollers.

This new bearing is ready for you right now from stock in two standard sizes (illustrated). Other sizes will be available later.

For complete specifications, ask for Data Sheet No. K562 — write, call or wire Kaydon of Muskegon.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 124" outside diameter . . . Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

Circle 414 on page 19

Full House!

...a setko self-locking set screw for every problem!

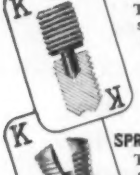
... And, every Setko Self-Locking set screw is an *ace* performer! Each one depends on a specific design principle to lock fast.

They provide positive locking action ... speed assembly and cut costs by utilizing standard driving techniques ... don't require special tapping. All are available in regular points, patented Nu-Cup point, and standard sizes and threads. With the Setko System, they can be hopper-fed in sizes as small as #2 (.086" x 1/8").

ZIP-GRIP® SET SCREWS
Exclusive Contra-Thrust action locks at any point. Solves problems of loosening due to wear, clearance in the thread, or vibration. Can be re-used.

OFFSET SET SCREWS
When driven, two offset edges in threaded portion exert powerful spring pressure. Not affected by extreme variations in tapped holes.

CREST-LOK SET SCREWS
New, original design doesn't require precise tapping. Can be re-used repeatedly. Amount of lock can be altered by changing tap drill size.



POINT-LOK SET SCREWS
This design ends top-screw loosening on two-screw applications. Lower screw can be locked with Point-Lok without disturbing original setting. Can be re-used.

SPRED-LOK® SET SCREWS
This design is for soft metal applications. Top is "spread" slightly to take up "flow" of soft metal. Can be re-used.

Other Setko Self-Locking set screws that solve specific problems include Flush-Lok, Wedge, Truncated and Jam-Lok. A complete description of Setko set screws including Nu-Cup and Self-Tapping, and the Setko System for hopper-feeding headless set screws is contained in Catalog 21. Write today for your free copy

Set Screw & Mfg. Co.
28 Main Street, Bartlett, Illinois

1583

Circle 415 on page 19

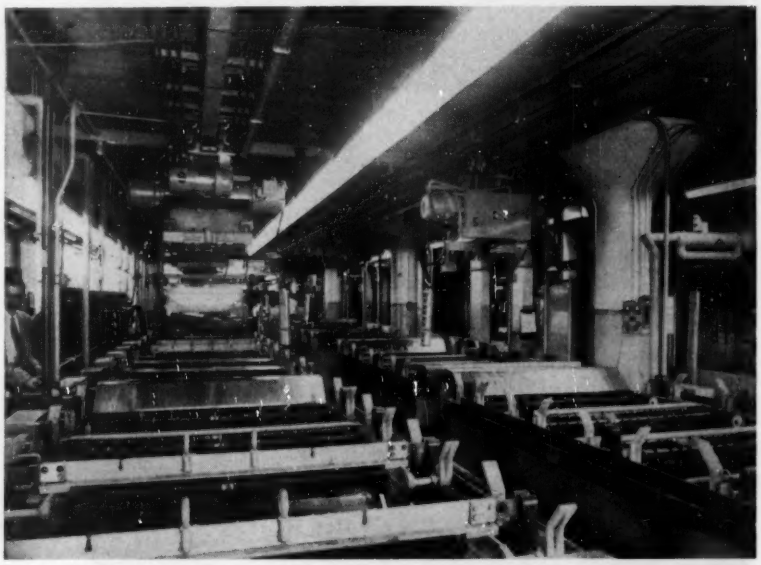
Engineering News Roundup

(*Continued from Page* 14)

cording to Dr. Van Horn.

The gold-plated battery is designed for long life and minimum discharge of power. It is 400 times more effective, in terms of space, than the mechanical mainspring.

The electric watch has about one-third fewer parts than the automatic watch which has gained great popularity in recent years. According to Hamilton, tests show that the day-to-day accuracy of the new electric watches is far greater than that of automatic or manually-wound types.



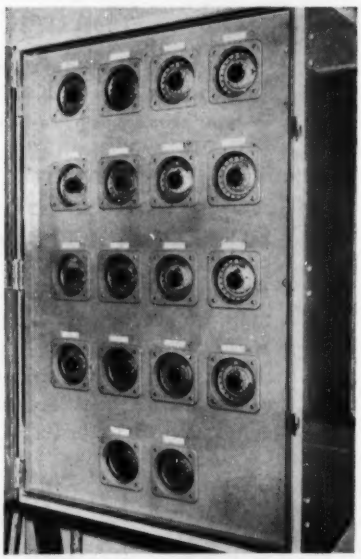
Tanks holding cleaning and plating solutions are arranged in an oval. Above them, a closed loop monorail carries power hoists cycled to do the work of lifting and transferring parts batches through processes.

Timer-Controlled Power Hoists Automate Plating Cycles

PHILADELPHIA, PA.—More output with less labor is now accomplished in the plating department of the Gillette Safety Razor Co. with power hoists cycled automatically through the processes from central time-controls. Installed by the Yale & Towne Mfg. Co., the control system replaces a rack plating process for small razor parts.

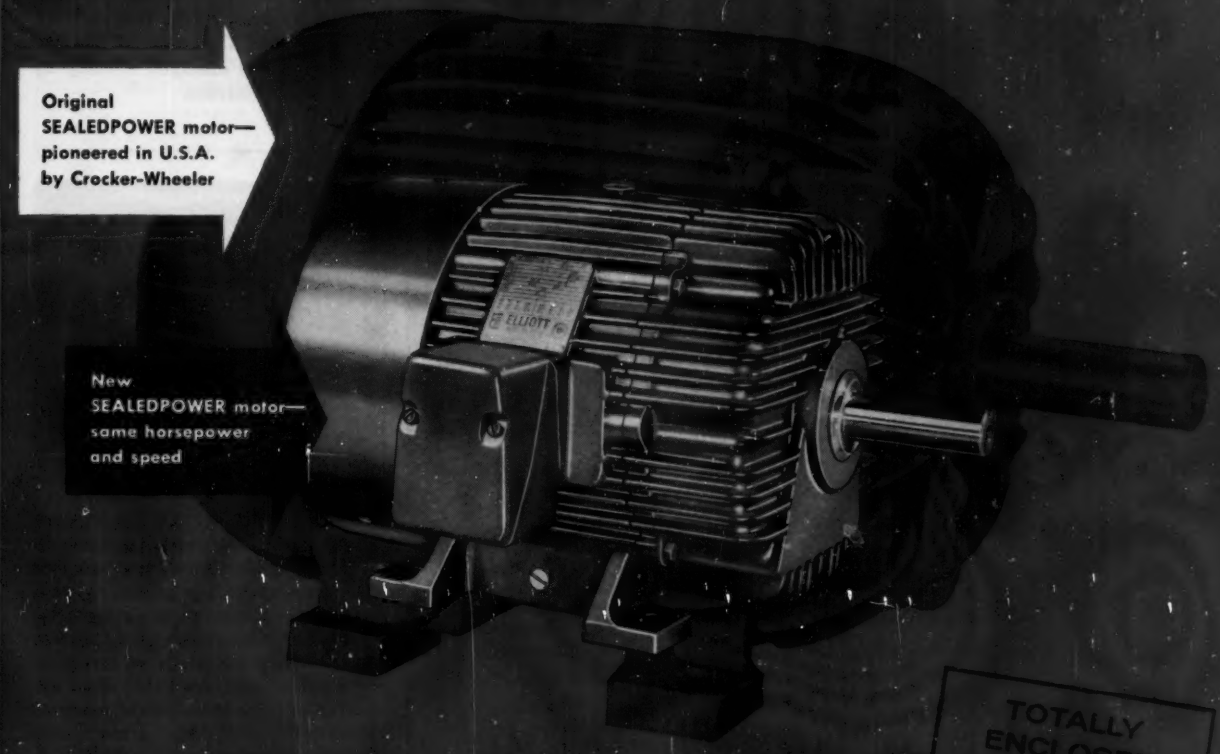
Processing and plating tanks are arranged in an oval. Above the tanks, six electric hoists travel on a closed loop monorail. The hoists carry barrels of parts in process and lift them in and out of the tanks.

Nerve center of the system is a panel of circuits and timers which control the movements of the hoists through the system and the dura-



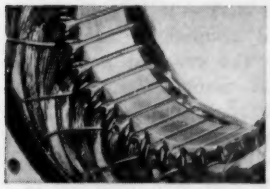
Timer controls and circuits are readily variable to accommodate changes in processes and different cycles for different parts or plates.

Inside and Outside . . . entirely new

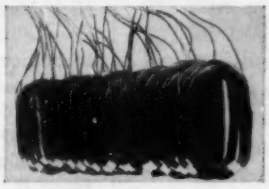

Original SEALEDPOWER motor—pioneered in U.S.A. by Crocker-Wheeler
New SEALEDPOWER motor—same horsepower and speed
TOTALLY ENCLOSED FAN-COOLED FRAMES 284U-326U

NEW Elliott SEALEDPOWER Motors Produce MORE POWER per POUND

Superior Insulation Improves Motor Performance



Stator slots are lined with new, revolutionary synthetic materials having greater dielectric and mechanical strength than those previously used.

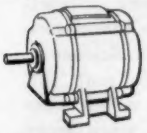


Motor coils are group-wound from continuous lengths of Vinylastic wire, with no brazed or soldered connections within groups.

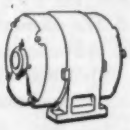
In the new Elliott Crocker-Wheeler Type N motors, better utilization of copper, insulation, and electrical steel produces more horsepower per pound than earlier designs.

This is one of the *balanced design* factors that contribute to the outstanding performance of these motors. Others are highest quality electric steel, rigid frames and brackets, choice of anti-friction bearings to suit your operating and maintenance conditions, and a variety of highly effective enclosures, including dripproof, totally-enclosed and explosion-proof designs.

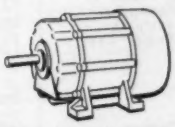
OTHER C-W TYPE N MOTOR ENCLOSURES



Totally-enclosed non-ventilated



Dripproof Protected



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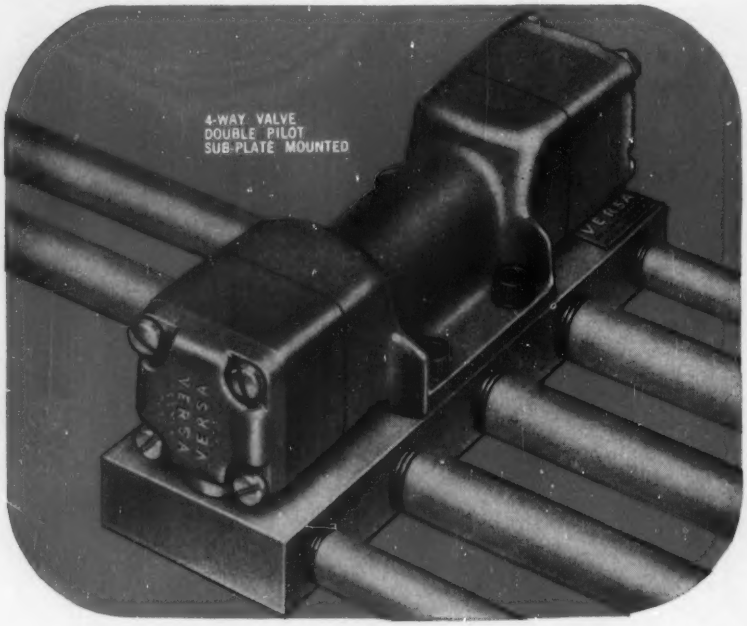
CROCKER-WHEELER DIVISION

WRITE **for new bulletin describing Elliott C-W Type N Motors. *Address:* Elliott Company, Crocker-Wheeler Division, Jeannette, Penna.**

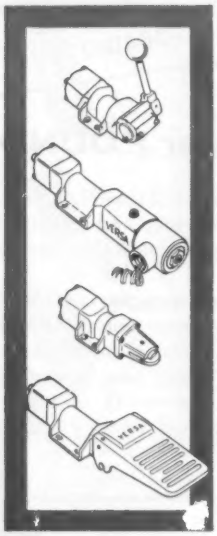
W6-7

Circle 416 on page 19

FOR MAXIMUM CAPACITY
IN MINIMUM SPACE . . .



THE VERSA
MANIFOLD MOUNT VALVE



The **Versa Manifold Valve** has been especially designed for use where space is at a premium.

All piping can be installed, connected to manifold plate and even purged before installation of the valve itself. The valve is then simply bolted into place on the manifold plate. The valve proper, being independent of the piping, can be easily removed for service or replacement without disconnecting piping or disassembling the valve.

Versa Control Valves are available with any type of actuating device in sizes from ⅛" to 1" NPT, in 2-, 3-, 4-, and 5-way type, and for pressures from partial vacuum to 500 PSIG.

All Versa Valves are triple pressure and functionally tested under water for guaranteed leakproofness.

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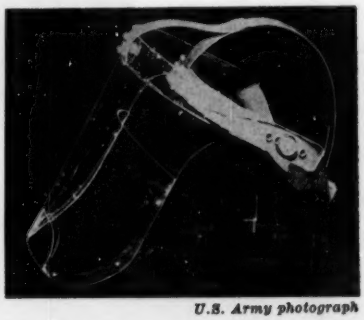
News Roundup

tion of phases in the operation. Versatility is an advantage claimed for the system, since the number and duration of phases in the operation can be changed readily at the central controls.



U.S. Army photograph

TO FACE THE COLD, Army troops who must work outdoors in extremely cold climates may use this new protective face shield. Developed at the Corps of Engineers' Research and Development Laboratories, the shield is made of transparent vinyl plastic. An inner frost apron back of the main shield prevents cloudiness resulting from condensed moisture of respiration. When necessary, the shield can be tilted upward through 90 degrees.

Science for All Students Equated to Arts for Engineers

NEW YORK, N. Y.—If this nation's science and technology are ever to achieve "the greatest good for the greatest number," some current educational trends must be reversed, a General Motors scientist warned recently. Dr. Lawrence R. Hafstad, vice president in charge of G-M Research Staff, made a plea for reviving classroom disciplines of science and mathematics for both technical and nontechnical high school students.

Dr. Hafstad spoke to the Scientific Research Society of America in connection with the annual meeting of the American Association for the Advancement of Science.

He explained that to reap full benefits of technology, a "good society" not only must train more scientists and engineers but also must make the basic philosophies

of science understandable to non-technical people.

He cited a recent Purdue University survey of high school student attitudes toward career scientists. The survey had indicated that varying percentages of students believed scientists are "odd," dishonest, incapable of enjoying normal lives, and willing to sacrifice the welfare of others to further their own interests.

The survey results indicated to Dr. Hafstad that the students had not gained an appreciation of the sciences as the foundations of modern civilization.

Dr. Hafstad said that his greatest concern was "a continuing divergence in point of view between the sciences and the humanities. This adverse tendency could be reduced by insuring that students of science were given a better grounding in the humanities, while students in the humanities were given a better background in science.

"Much of the energy of our

Answers to questions on gray iron castings, Page 6:

1. "Makes no difference" is the right answer. If a casting is not well cleaned, leaving it out doors will help machinability, because some of the hard, black oxide and adhering sand, if any, would be loosened by rusting. If there are extreme temperature variations outdoors, this could have a very slight stress-relieving effect, but this would not change the casting's machinability.

2. "Standard" specifications go up to 60,000 psi tensile strength. However, with heat treatment the strength of gray iron castings can be raised considerably above the "as cast" strength. This is true of all classes of gray iron.

3. Tensile strength at 120,000 psi for ductile irons shows up in the Society's Summary of Specifications. It should be noted, however, that 120,000 psi tensile is achieved only by heat treatment.

4. More is being learned on this subject all the time. Until recently, conservative engineering limited pressure-containing parts to 450 F. Now, 650 F is accepted for this application, and gray iron parts in nonpressure applications are in satisfactory use under steady loads at temperatures of 800 F.

5. For all practical purposes, cast crankshafts are no heavier than forged. In fact, in many cases they end up lighter in weight since the specific gravity of gray iron is a little less than steel. One of the reasons is that in order to get the necessary bearing surface, forged crankshafts are made thicker than they have to be for strength alone.

6. There is no such thing as "semisteel" in the technical sense. Years ago when certain progressive gray iron foundries began controlling their processes and consistently produced higher strength castings, they called them semisteel to differentiate them from the low-strength iron which was otherwise available. The term has persisted since then.

7. This is a relative thing, but 0.003-in. per in. is common in shell molding. In medium and large castings, even closer tolerances are held. With care, gray iron foundries often achieve 0.005 to 0.010-in. per in. tolerances with green sand molding. Quality of patterns as well as foundry practices enters into the picture.

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TYPE 11-A

Synthetic Rubber Bellows • Small shafts to ¾ in.

Services: hot or cold water, oil, gasoline, kerosene and other liquids non-injurious to synthetic rubber.

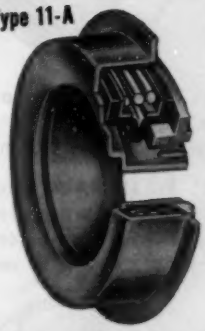
Pressures: up to 50 psi.

Temperatures: –65°F. to +220°F. Special construction to +300°F.

Construction Data: Packaged unit. Retainer does not contact shaft, permitting operation at a high rpm. One size can be used for several shaft sizes. Bellows encloses spring and metal parts to prevent contact with medium being sealed.

TYPE 6-A

Synthetic Rubber Bellows • Interchangeable with Type 11-A



Services: hot or cold water, oil, gasoline, soapy and other liquids non-injurious to synthetic rubber.

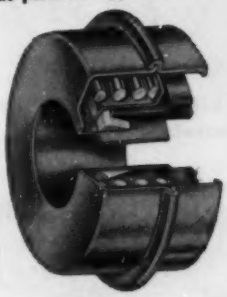
Pressures: up to 75 psi.

Temperatures: –65°F. to +220°F. Special construction to +300°F.

Construction Data: Similar to Type 11-A. Does not contact shaft, permitting operation at high rpm. One size can be used for several shaft sizes. Spring and metal parts available in stainless steel or bronze.

TYPE 9-A

Sealing Members Made of Teflon* • Engineered for the particular application



Services: all chemicals, solvents, oils, corrosives and gases, hot or cold.

Pressures: to 150 psi. Balanced construction to 750 psi.

Temperatures: –120°F. to +500°F.

Construction Data: Packaged unit. Furnished in metallurgical specification best suited to the application. Chemically-inert Teflon wedge ring closely fits inner sleeve of retainer and is machine-mated to carbon sealing washer.

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Circle 418 on page 19

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PRECISION BALLS AND
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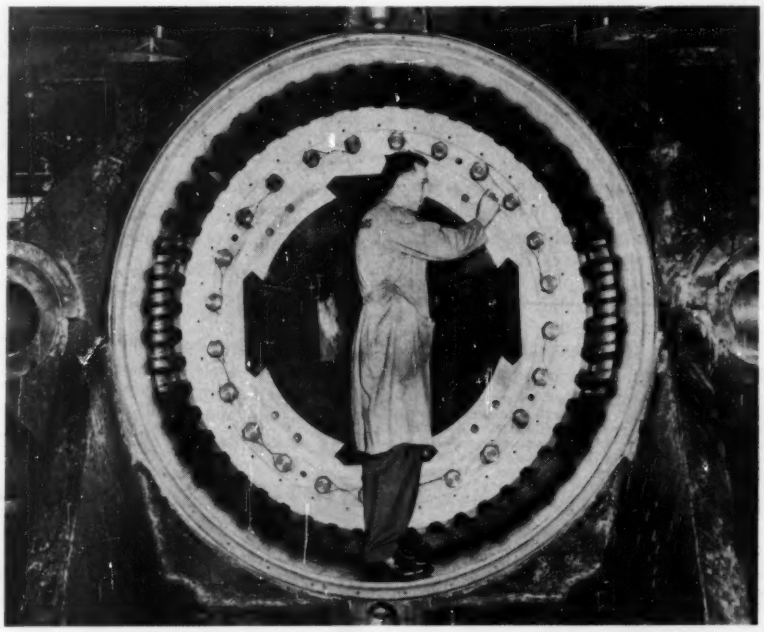
Circle 457 on page 19

educational system these days is focused on new theories of teaching which . . . avoid grading and thus . . . conflict or competition. This is desirable sociologically, but apparently so is a rising standard of living. This presents a painful choice. In techology, if incentive is removed, so is struggle—and if struggle is stopped, so is progress.

"The desire for 'progress' cannot be reconciled with the lack of attention to, and an incentive for, students of exceptional ability," Dr. Hafstad explained. "Similarly the desire for 'progress' is inconsistent with the trend toward effortless education with the substitutions of pastimes for disciplines."

He urged an intellectual "matching of backgrounds" between scientists and humanitarians so that the nontechnical portion of society will comprehend the scientists' motives. "Even more acute than the current shortage of scientists and engineers is the shortage of people who can and will carry responsibility."



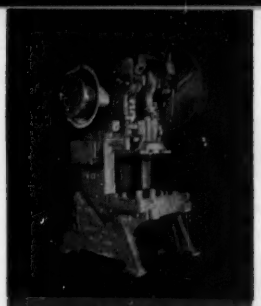
MOST POWERFUL GEARSET ever designed and built by Cone-Drive Gears Div. of Michigan Tool Co. is this assembly with 20-million lb-in. running-torque rating, 30-million lb-in. static-torque rating. Two worms drive the double-enveloping gearset with center distance of 44 in. To obtain the same torque with conventional cylindrical worms, a center distance of 55 to 60 in. would be required. This unit is part of a 1500-ton stretcher, companion to a 12,000-ton extrusion press. The machines form aircraft parts.

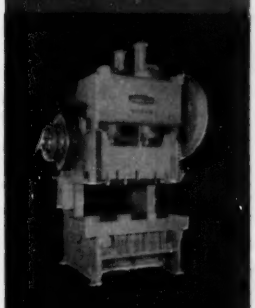
Museum Displays Popularize Mathematics

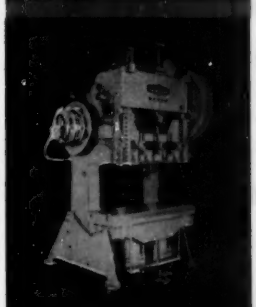
Abacus, Computer in Exhibits

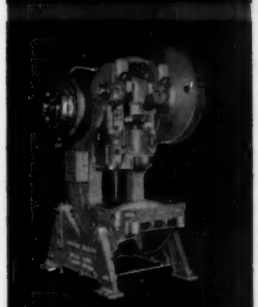
CHICAGO, ILL. — Colorful exhibits that show the significance of mathematics in the modern world and career opportunities available to those trained in mathematics recently went on display at the Museum of Science and Industry. More than two dozen displays furnished by IBM comprise the exhibit, called the "World of Numbers."

One feature of the exhibit is the cycloramic staging of Project Sage, the nation's electronic air defense system. Here, by simply lifting a telephone, the visitor puts









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Take your pick of any Johnson Press using an air clutch and you'll find it is equipped with a WICHITA CLUTCH. WHY? Because WICHITA CLUTCHES have become standard equipment at Johnson.

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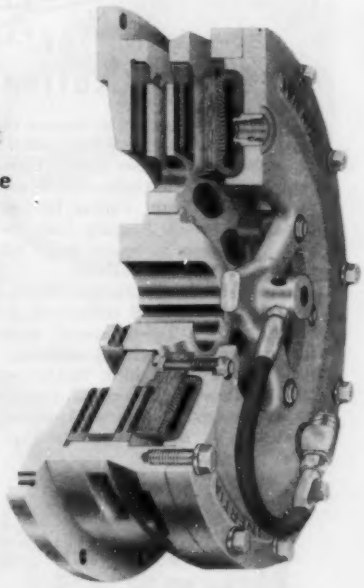

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Elkhart, Indiana

WICHITA Clutch COMPANY, INC.
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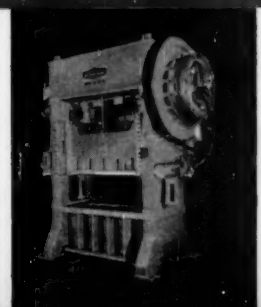

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Robert R. King Co., Cleveland, Ohio
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Dominion Power Press Equipment Ltd., Graham's Lane Burlington, Ontario, Canada
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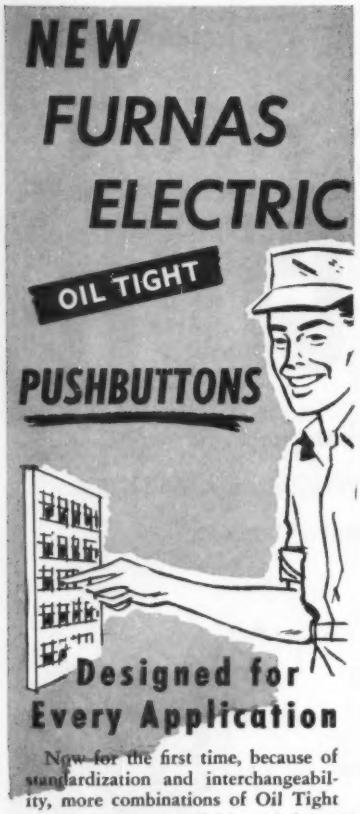

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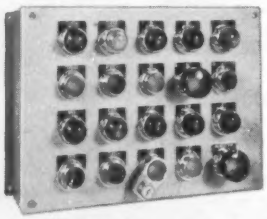
Accessories (key lock, mushroom head or lever) are mounted directly on all standard operators. Operators need not be modified or removed from panels.



For full information write for Catalog 5606, Furnas Electric Company, 1045 McKee Street, Batavia, Illinois.

A17

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Circle 419 on page 19

Engineering News Roundup

into operation a simulated air attack by enemy bombers. The three-dimensional display and film shows how information is relayed with lightning-like speed from early warning radar stations and ground observer posts to Air Defense Command Centers. At these Centers, the Sage computer, fastest in the world, calculates the speed, course, and altitude of the approaching enemy planes in a millionth of a second. Within minutes, jet interceptors, Nike missiles, and coastal antiaircraft batteries go into defensive action with exact knowledge of where the enemy is, where he is headed, and when he will reach the point of interception.

A number of test-type panels provide entertainment and instruction in a lighter vein. One asks, "What's your M. Q.?" (mathematics quotient). This is an aptitude test with ten mathematical questions on a translucent panel and ten pairs of buttons below to register "true or false" answers. The panels are especially planned to lift mathematics out of a prosaic, textbook atmosphere and present it as an active, interesting subject. They illustrate problems in algebra, trigonometry, and other basic mathematical processes.

The earliest calculating device known—the abacus—is presented in giant size. It is mechanized so that the visitor, by merely pushing a lever, can easily learn how men calculated many centuries ago. In contrast, the IBM 705 Electronic Data Processing Machine is presented in model form.

A translucent wall diagram helps the visitor to see exactly how the modern computer works. Here, a voice gives a concise, step-by-step explanation of how problems are presented to the machine, how they are solved internally, and how the answers are produced. As the narration proceeds, pictures in the diagram are illuminated to show the progress of the problem through the system.

One of the panels explains the binary number system, often used in computers because it requires the least possible number of tubes to represent any given value. The machines are designed to take in decimal numbers, convert them to binary, compute in binary, and deliver the answers in decimal.

In a case adjoining the computer model, different memory devices are shown and explained. Suspended from the ceiling of the exhibit are models of geodesic domes.

THREE-RAIL PILE, introduced by L. B. Foster Co., has demonstrated exceptional strength compared to conventional type, particularly during driving. Three steel rails are welded together at the base edges.

Meetings

AND EXPOSITIONS

Feb. 4-8—

American Society for Testing Materials. Annual Committee Week and Spring Meeting to be held at the Benjamin Franklin Hotel, Philadelphia. Additional information is available from society headquarters, 1916 Race St., Philadelphia 3, Pa.

Feb. 5-7—

Society of the Plastics Industry Inc. Twelfth Annual Technical and Management Conference of the Reinforced Plastics division, to be held at the Edgewater Beach Hotel, Chicago. Further information is available from society headquarters, 250 Park Ave., New

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Solid steel or bronze; steel faced with babbitt or copper-lead, or copper-lead on *both faces*. Flat, spherical or special shapes. Grooves, holes, nibs, scallops or lugs. O.D. 1″ to 6″. Wall thickness: solid, .028″ to .141″; bimetal, .034″ to .141″. Cold rolled for heavy-duty. Large capacity. Complete engineering service.

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Circle 420 on page 19

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New ASPIRATOR ACTION

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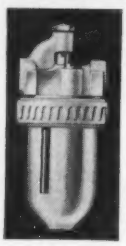
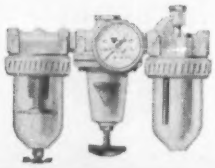
WATTS high efficiency LUBRICATOR



New BY-PASS PICKUP

Watts new By-Pass Pickup makes possible an exclusive high velocity venturi section which vaporizes virtually 100% of the metered oil. By-Pass permits maintenance of constant pressure in the venturi section with minimum pressure loss.

Complete range of Sizes: 1/4", 3/8", 1/2"



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News Roundup

York 17, N. Y.

Feb. 15-16—

National Society of Professional Engineers. Spring Meeting to be held at Hotel Francis Marion, Charleston, S. C. Further information is available from society headquarters, 2029 K St., N. W., Washington 6, D. C.

Feb. 24-28—

American Institute of Mining, Metallurgical and Petroleum Engineers. Annual Meeting to be held at the Hotel Jung, New Orleans. Additional information can be obtained from the institute's headquarters, 29 W. 39th St., New York 18, N. Y.

Feb. 25-March 1—

American Society of Heating and Air-Conditioning Engineers. 13th International Heating and Air-Conditioning Exposition to be held at the International Amphitheater, Chicago. Further information is available from International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Feb. 26-27—

Third Conference on Radio-Interference Reduction to be held at Armour Research Foundation of Illinois Institute of Technology, Chicago. Further information can be obtained from the foundation, Technology Center, 10 W. 35th St., Chicago 16, Ill.

Feb. 26-28—

Western Joint Computer Conference to be held at the Statler Hotel, Los Angeles. Sponsors are Institute of Radio Engineers, American Institute of Electrical Engineers and Association for Computing Machinery. Further information can be obtained from S. Dean Wanlass, Aeronutronic Systems Inc., 13729 Victory Blvd., Van Nuys, Calif.

March 5-7—

Society of Automotive Engineers Inc. National Passenger Car, Body and Materials Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from so-

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ciety headquarters, 29 W. 39th St., New York 18, N. Y.

March 6-8—

Pressed Metal Institute. Annual Spring Technical Meeting to be held at Hotel Carter, Cleveland. Further information is available from institute headquarters, 3673 Lee Rd., Cleveland 20, O.

March 11-14—

1957 Nuclear Congress and International Atomic Exposition, to be held at Convention Hall, Philadelphia. This second nuclear engineering and science conference, sponsored by 20 technical societies, is co-ordinated by the Engineers Joint Council. Further information can be obtained from the Council, 29 W. 39th St., New York 18, N. Y.

March 11-15—

National Association of Corrosion Engineers. Thirteenth Annual Conference and Exhibition to be held at Kiel Auditorium, St. Louis. Additional information can be obtained from association headquarters, 1061 M & M Bldg., Houston 2, Tex.

March 18-20—

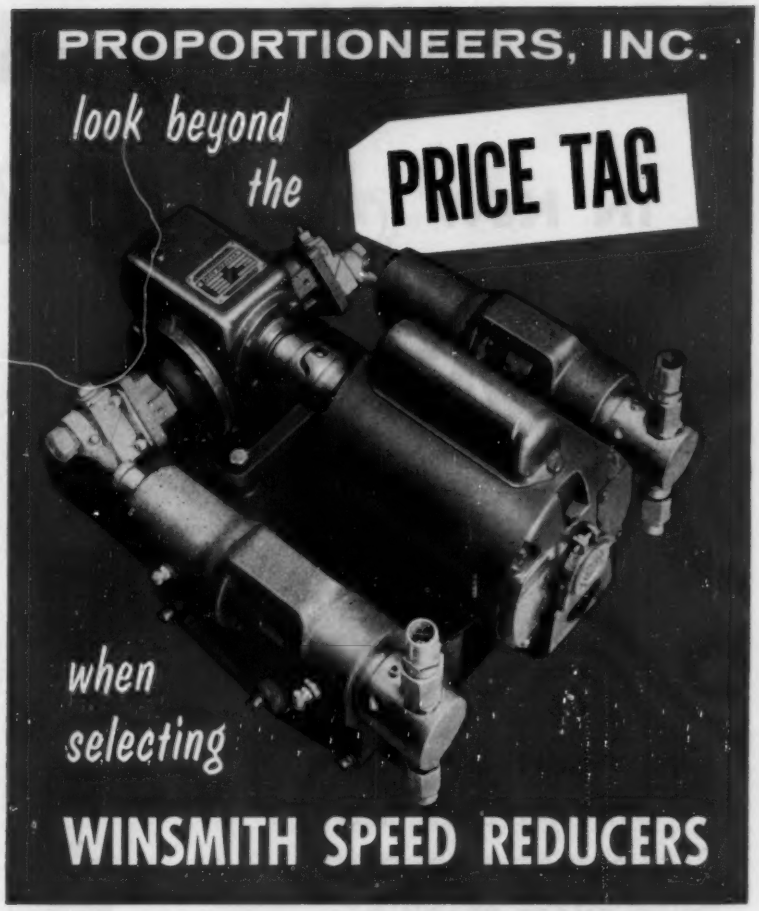
American Society of Mechanical Engineers. Gas Turbine Power Conference to be held at the Sheraton-Cadillac Hotel, Detroit. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

March 18-21—

Institute of Radio Engineers. National Convention to be held at the Waldorf Astoria Hotel, New York. Additional information can be obtained from institute headquarters, 1 E. 79th St., New York 21, N. Y.

March 25-29—

Tenth Western Metal Exposition and Congress to be held at the Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles. Sponsors are American Society for Metals and other technical groups. Additional information is available from ASM headquarters, 7301 Euclid Ave., Cleveland 3, O.



● Wherever fluid proportioning is used in industry, the Model 1106 Proportioneer Pump is known for its work-horse stamina, its watch-like accuracy. Helping to build this reputation for ruggedness and precision, Winsmith Speed Reducers have been selected for use on these pumps since 1932.

Proportioneers, Inc., a division of B-I-F Industries, rate performance as the main reason for continued selection of Winsmith reducers but in looking beyond the price tag and the performance they pay for — they find a highly important *extra* that's not for sale but given freely at Winsmith — that's *co-operation* in helping customers to solve speed reducer problems.

As Proportioneers, Inc., puts it: *"... co-operation is one of those things that can't be covered by a price tag but it is one of the big reasons why we have stayed so long with Winsmith."*

When you select Speed reducers, keep this *extra* in mind. The services of our engineering department are always at your service to help you select the right reducer for every application from 1/100 to 85 h.p.

WINSMITH SPEED REDUCERS

WINSMITH, INC.
16 Elton Street
Springville (Erie County) N. Y.

Circle 422 on page 19

GRAMIX® BRONZE BEARINGS AND IN NEW Sunbeam PRODUCTS

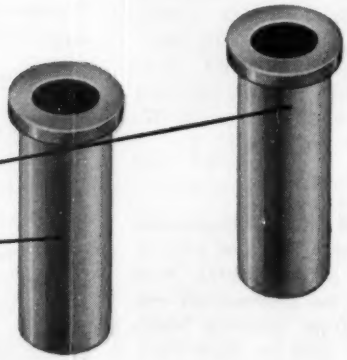
GRAMIX® ALLOYS

(PRODUCT OF POWDER METALLURGY)

The new Sunbeam Mixmaster Junior* does kitchen mixing chores quickly and efficiently and one of the important factors in its fine performance is the use of GRAMIX bearings on the beater spindle shafts. These sintered metal bearings, which are produced from GRAMIX Grade 81 alloy, are oil-impregnated for self-lubrication and are quiet running in operation. One of the outstanding features of these GRAMIX bearings is the fact that they are exceptionally long in relation to the comparatively small diameter. Yet there is no taper or "bell mouth" effect present and tolerances are held to .001 on both the ID and OD. The bearing offers maximum load-carrying surface throughout its length. In addition, Sunbeam engineers have found that GRAMIX gives them a controlled, consistent density in all sections of the bearing. This is another case where GRAMIX bearings have been specifically engineered and produced to fit the needs of the application. Can the same be done for your products?

**Made and guaranteed by the Sunbeam Corporation, Chicago, Illinois*

NEW SUNBEAM MIXER WITH GRAMIX SELF-LUBRICATING BRONZE SHAFT BEARING



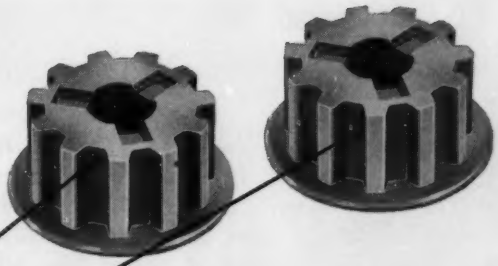
117

THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

GRAMIX® IRON SPROCKETS

PROVE VERSATILITY OF



In the new Sunbeam twin blade electric lawn mower, power is transmitted from the motor to the cutting blades via cog belt drives. Among the most important parts in this power transmission system are a pair of drive sprockets which must stand up under hours of rugged operation. For these critical parts, Sunbeam Corporation engineers have specified GRAMIX sintered metal sprockets produced to their exact specifications from GRAMIX iron alloy 78. This dual purpose part acts as both a bearing and a sprocket. The excellent bearing characteristics of this GRAMIX alloy eliminates need for special inserts etc., yet the sprocket itself withstands shock loading and maintains a constant coefficient of friction. The contour of the sprocket teeth is maintained under the most severe operating conditions. Additional benefits that Sunbeam engineers have found in GRAMIX include the compatibility of GRAMIX with the belt material and the fact that there is less operational noise. Again, this is a case where the GRAMIX process has produced a part specifically engineered to meet exact product requirements . . . why not investigate the advantages of GRAMIX parts for your designs?

WRITE FOR THIS BOOK

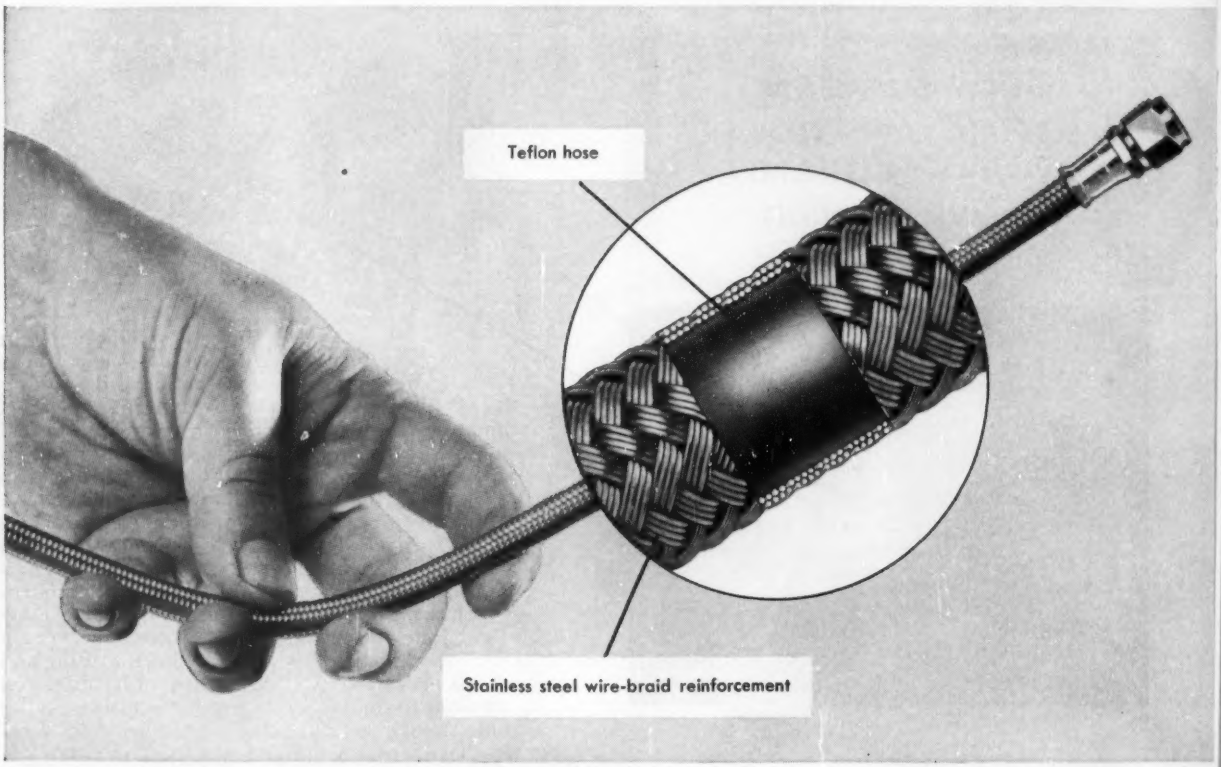
Because GRAMIX parts are die-pressed to shape, then sintered, they are usually much more economical than machined parts. Tolerances as close as .0005" can be held, and the parts oil-impregnated for self-lubrication. Other facts of value to the manufacturer and the design engineer are contained in GRAMIX Engineering Bulletin No. 21. Write today to The United States Graphite Company, Saginaw, Mich.

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

NOW! A Tough Material To

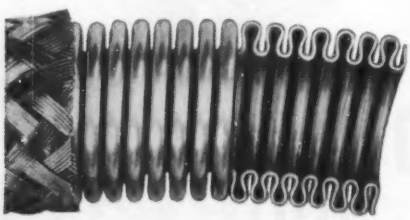
Introducing AMERICAN FLEXIBLE



NAME YOUR PROBLEM. American has the flexible connector to meet it.

AMERICAN SEAMLESS

Easily installed, low-maintenance, long-life tubing of bronze, carbon steel, stainless steel, Monel, cupro nickel, brass and other workable metals solve most flexible connector problems involving steam, oil, liquids, gases, etc., under pressure; for absorbing vibration in rigid pipelines, connecting misaligned ports; for piping in limited space and service where there is intermittent or continuous flexing.



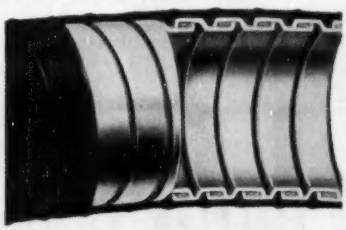
AMERICAN STRIPWOUND

Combines all-metal strength with extreme flexibility, permitting easy installation and handling. Made in bronze for conveying steam and water, in steel for conveying oil, tar, asphalt, etc., and in copper, aluminum, carbon steel, stainless steel, and other metals for special applications. With or without wire braiding.

AMERICAN SEALTITE†

Flexible, liquid-tight conduit. Protective raceway for electrical wiring, made of a flexible galvanized steel core with tough extruded plastic jacket. Completely liquid-tight, resists chemicals. Absorbs movement, vibration, simplifies installation in tight spaces or where there is offset.

†Trademark



Meet Tough New PROBLEMS TEFLON HOSE

Heat-resistant, corrosion-proof, lightweight Teflon* flexible hose absorbs vibration, takes up movement, simplifies offset connections and installations in cramped spaces

FOR AIRCRAFT, GUIDED MISSILES AND ATOMIC ENERGY FIELDS. American Flexible Teflon Hose offers the double advantage of economy and longer life in many applications: fuel lines, oil lines, oxygen lines, hydraulic lines and others.

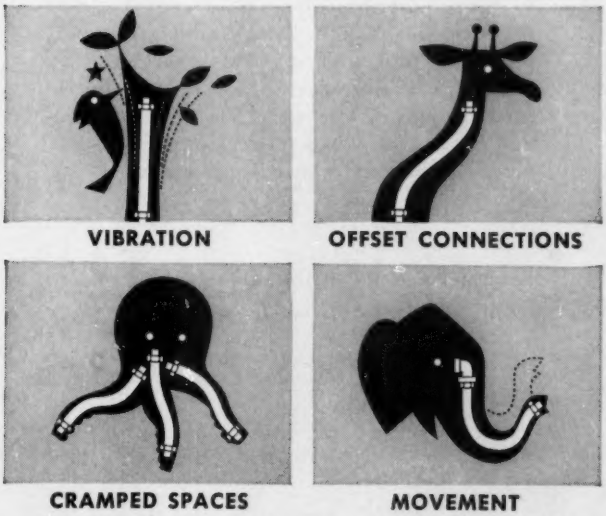
Properties include complete tightness under high pressures, high resistance to fatigue, torsion and corrosion, light weight and capability of continuous service in temperatue range of—100°F. to 500°F. Unaffected by any known type of fuel, oil, or acid within the temperature range of the hose.

FOR TOUGH INDUSTRIAL JOBS. American Flexible Teflon Hose promises long, economical service in many industrial applications. It is ideal where lines are subjected to outdoor exposure or attack by chemicals, or where high temperatures are a factor—either in the material being conveyed or plant surroundings.

HOW CAN YOU USE AMERICAN FLEXIBLE TEFLON HOSE TO REDUCE COSTS OR IMPROVE PRODUCT SERVICE? American Metal Hose engineers will be glad to consult with your engineers. Write for bulletin TF-100, or call: The American Brass Company, American Metal Hose Division, Waterbury 20, Connecticut. In Canada: The Canadian Fairbanks-Morse Company, Ltd.

*DuPont trademark for its tetrafluoroethylene resin

Contact American to solve problems of . . .



WHEREVER CONNECTORS MUST MOVE

AMERICAN

FLEXIBLE METAL AND TEFLON HOSE AND TUBING

AN

ANACONDA®

PRODUCT

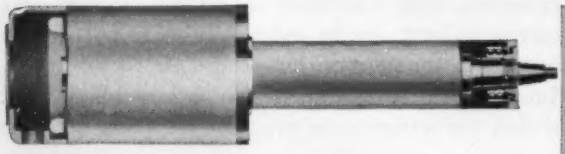
Circle 424 on page 19

SEE FOR YOURSELF

why you can be sure of...

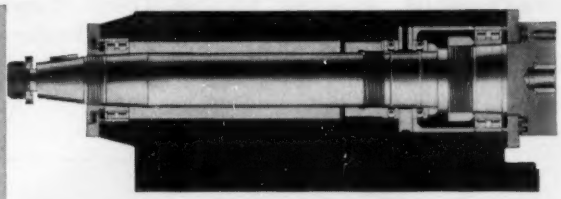
- **LOW MICROINCH SURFACE FINISHES**
- **TOLERANCES DOWN IN THE MILLIONTHS**
- **INCREASED PRODUCTION**
- **LOWER COSTS**

when you specify... **POPE PRECISION SPINDLES**



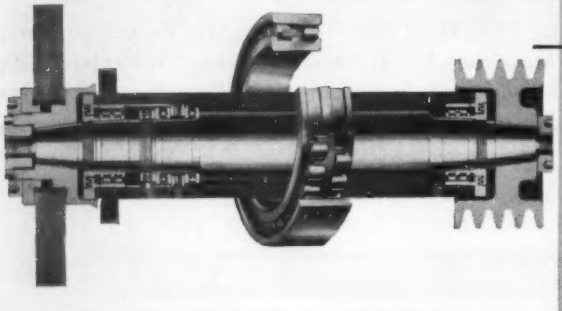
FOR SURFACE GRINDERS—

POPE 1, 2 and 3 HP, Totally Enclosed 1800 and 3600 RPM Motorized, Cartridge Type Spindles with massive shafts and big, double row cylindrical roller bearings having enormous capacity, superior performance and long life.



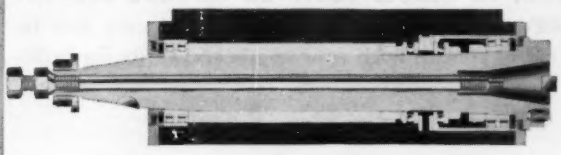
FOR BORING ROUND HOLES WITHIN MILLIONTHS OF AN INCH

POPE Heavy Duty Boring Spindles for smooth, chatter free, continuous high production of accurate parts. Again, look at the big cylindrical roller bearings and thrust bearings.



FOR CYLINDRICAL GRINDING—

POPE Cartridge Type and Wheel Head Belt Driven Spindles with the capacity to produce more work whether you plunge grind with a crush dressed wheel, remove surplus metal, or produce low microinch surface finishes. Note the super-precision radial bearings and ball thrust bearings.



FOR HEAVY DUTY MILLING—

POPE Spindles have the double row cylindrical roller bearings for the extra rigidity to support the cutting tool, and the double direction thrust bearings with the excess capacity to stabilize the shaft against endwise movement in either direction. This adds up to longer cutting tool life, more production, lower cost per piece.

POPE engineers and builds standard and special, precision anti-friction bearing Spindles for every purpose. Send us your specifications for prompt quotations.

No. 115

Specify **POPE®** PRECISION SPINDLES

POPE MACHINERY CORPORATION

Established 1920

261 RIVER STREET · HAVERHILL, MASSACHUSETTS

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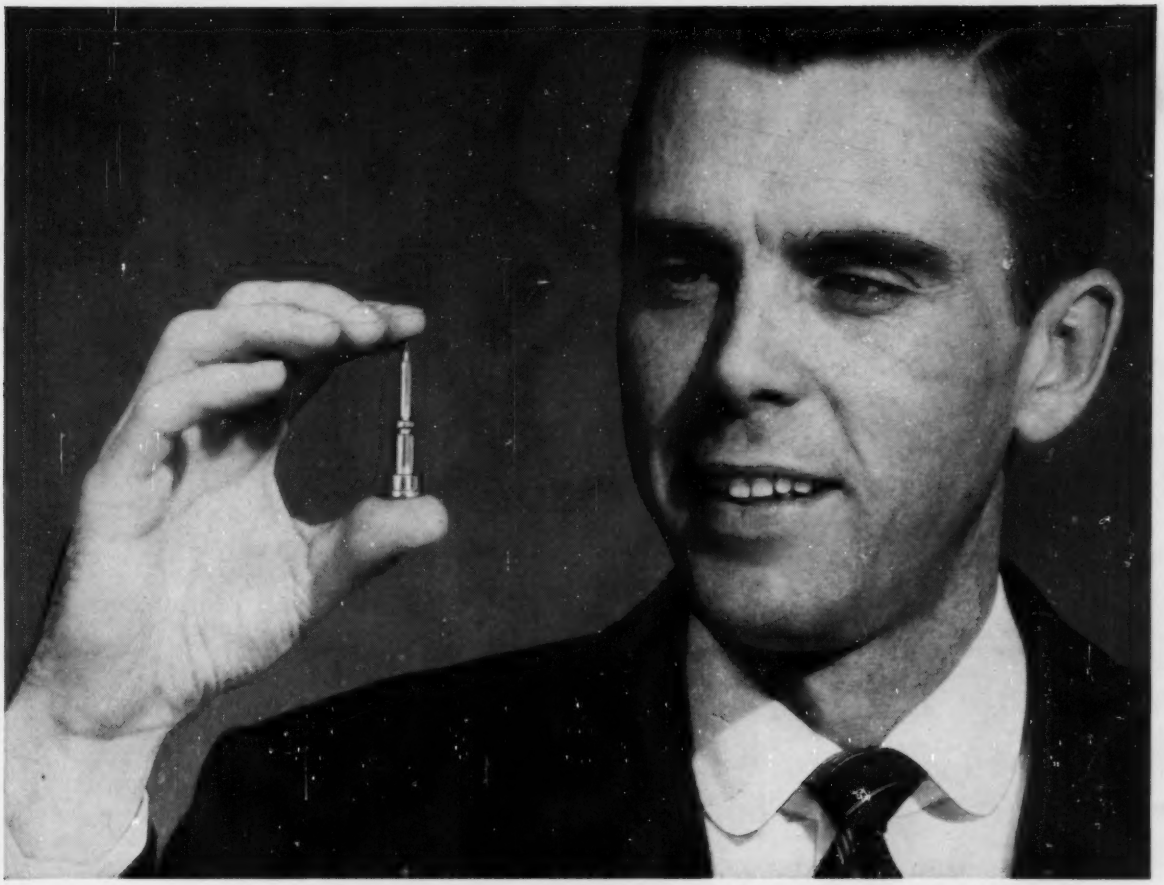


How better machinability in *Carpenter* Stainless changed the machinists' opinion of this design

Designing these seating valves for accurate service and ease of production called for something extra in machinability and uniformity of the stainless steel used.

Tolerances of .0005" on the parts were very important to successful operation and long service life. The length of the parts made it difficult to cut the threads on the small ends. With the ordinary Type 303 stainless first used, production costs were too high and rejects were excessive.

A change to Carpenter Stainless No. 8 (Type 303) proved to the production men that the design was a good one. No. 8 takes the tricky machining operation at profitable production speeds . . . meets the close tolerance requirements consistently . . . and holds rejects to a minimum. The company also likes the bright finishes No. 8 provides.

Try designing with Carpenter Free-Machining Stainless Steels in mind. Drop us a line on your company letterhead for complete, easy-to-use fabricating information.

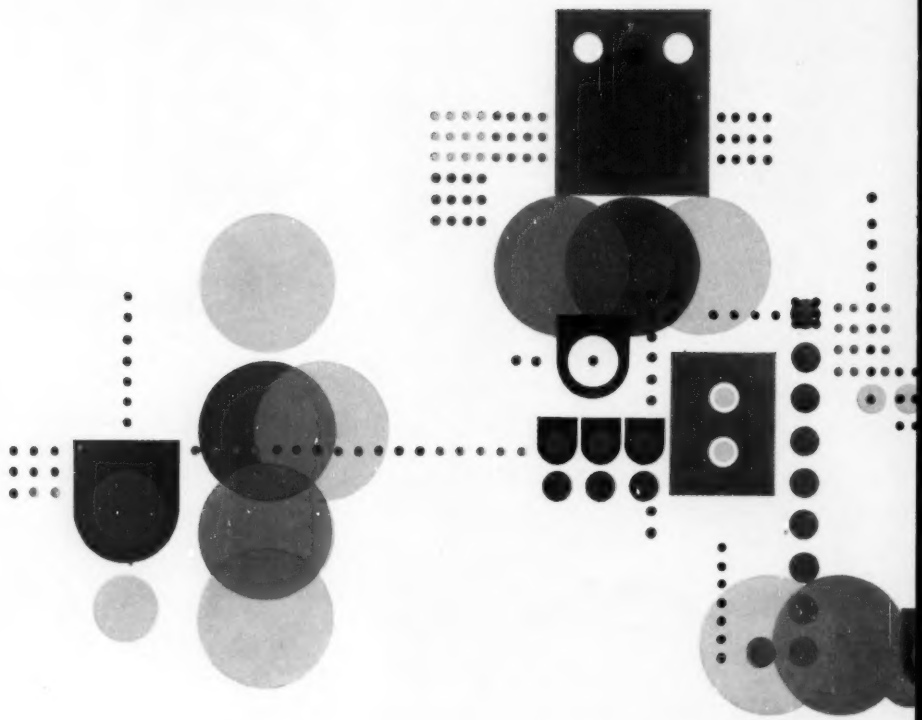
Carpenter STEEL

Free-Machining Stainless Steels

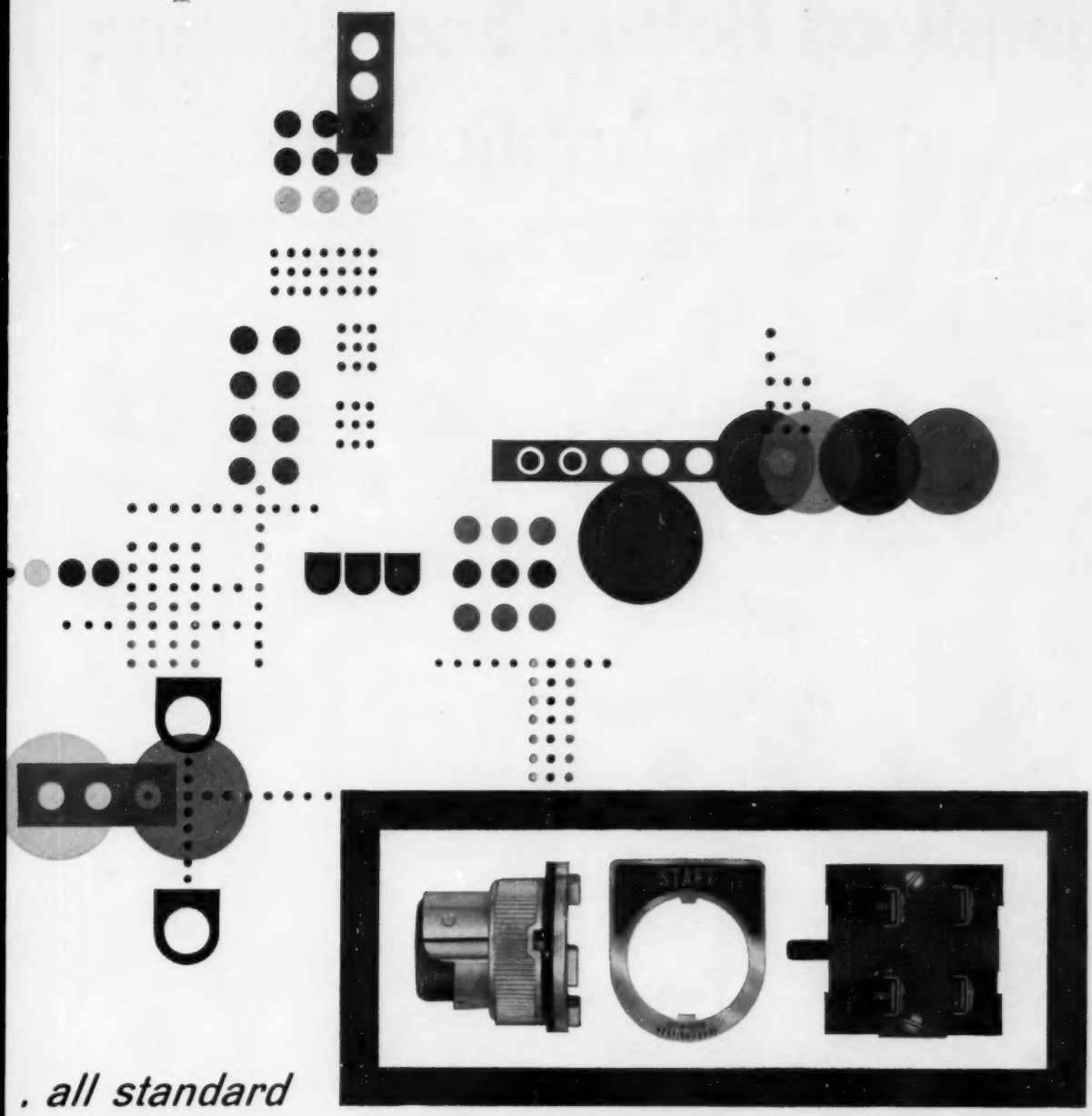
The Carpenter Steel Company, 120 W. Bern St., Reading, Pa.
Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Circle 426 on page 19

Circle 427 on page 19→



Pushbutton control arrangements almost to infinity .



. all standard

How'd you like a stock of 1,500,000 pushbutton controls on hand at all times for original equipment needs or for production purposes?

Sound prohibitive space-wise, or too expensive? Not at all. Just 38 Westinghouse components (shown above) do it because all parts are standardized and interchangeable. And always available from stock.

If you need controls for any application, write for the free 72-page *Pushbutton Guide*, B-6749. For control where moisture is a problem, write for free Booklet, B-7022, about Oil-Tite* controls. Write to Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. Or call your Westinghouse Distributor.

*T. M.

J-30248

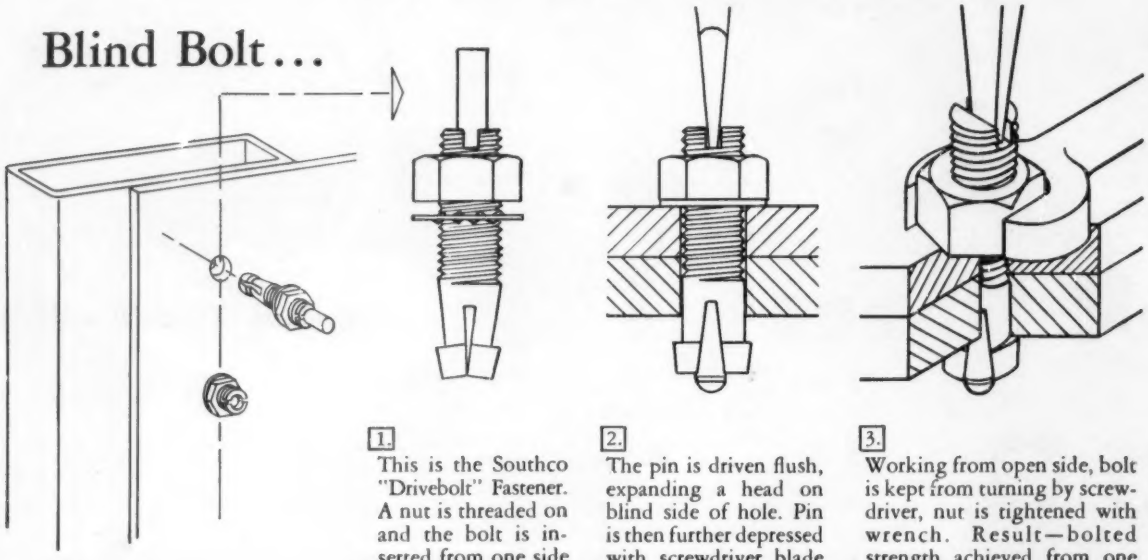
YOU CAN BE SURE... IF IT'S

Westinghouse

Simplified Bolting and Riveting in Blind Applications

For fastener applications accessible only from one side of the work, you can now bolt or rivet without special tools . . .

Blind Bolt . . .

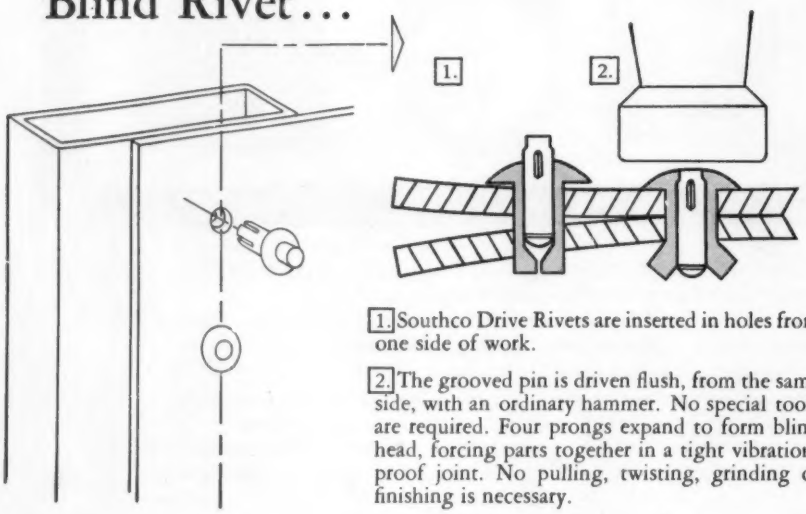


1. This is the Southco "Drivebolt" Fastener. A nut is threaded on and the bolt is inserted from one side of the work.

2. The pin is driven flush, expanding a head on blind side of hole. Pin is then further depressed with screwdriver blade to clear slot.

3. Working from open side, bolt is kept from turning by screwdriver, nut is tightened with wrench. Result—bolted strength achieved from one side of job.

Blind Rivet . . .



1. Southco Drive Rivets are inserted in holes from one side of work.

2. The grooved pin is driven flush, from the same side, with an ordinary hammer. No special tools are required. Four prongs expand to form blind head, forcing parts together in a tight vibration-proof joint. No pulling, twisting, grinding or finishing is necessary.

FREE!

Fastener Handbook

Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other special fasteners. Fifty-two pages, in two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS

LION

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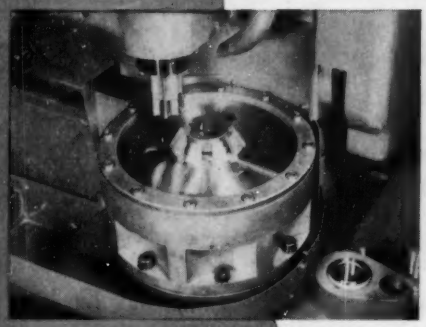
Circle 428 on page 19

How Gear Shaper *Versatility* helps IMPROVE DESIGN

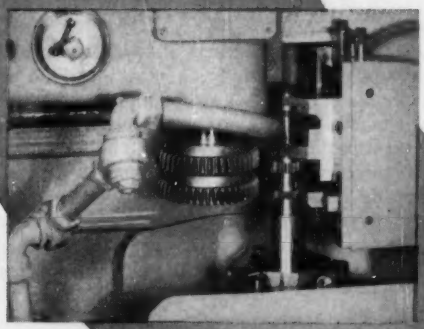


Quick-acting, air-operated diaphragm chuck speeds loading and unloading of pump rotor on Fellows No. 7A-Type Gear Shaper.

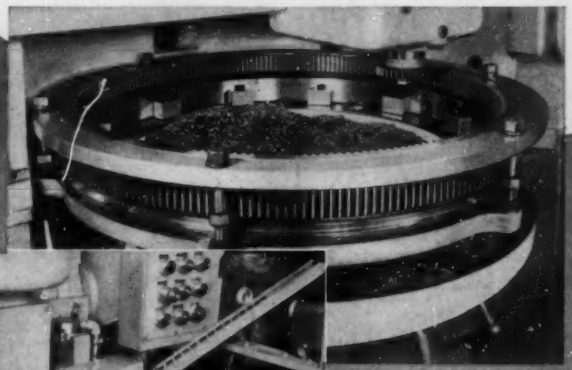
The Gear Shaper principle of generating with a reciprocating tool provides a versatile and economical method of manufacture which allows the engineer much greater latitude in the design of parts for low cost production. Special fixtures and controls permit cutting gears, intricate contours and other shapes in tandem or combination where otherwise, special-purpose machines might be required.

Free booklet — "The Art of Generating with a Reciprocating Tool" — shows in engineering detail how you can use Fellows Gear Shaper versatility to simplify and improve design. Write for it now.

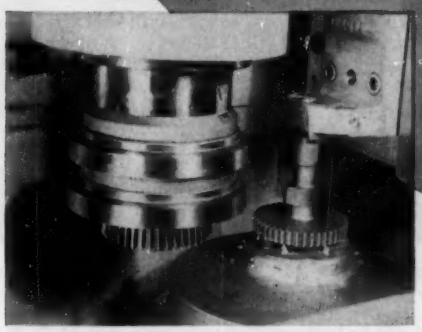
THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices: 1048 N. Woodward Ave., Royal Oak, Mich.
5835 W. North Ave., Chicago 39
150 W. Pleasant Ave., Maywood, N. J.
6214 W. Manchester Ave., Los Angeles 45



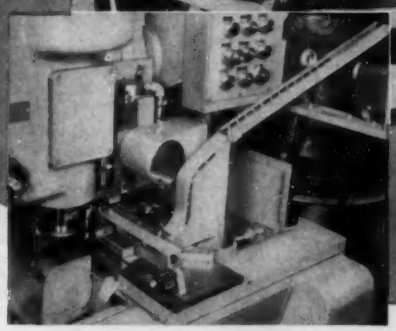
Two Gear Shaper Cutters in tandem cut automotive gears simultaneously. Center support fixture holds part in No. 4GS Gear Shaper.



Special fixture holds combination internal-external gear while internal gear is cut on 36-Type Gear Shaper.



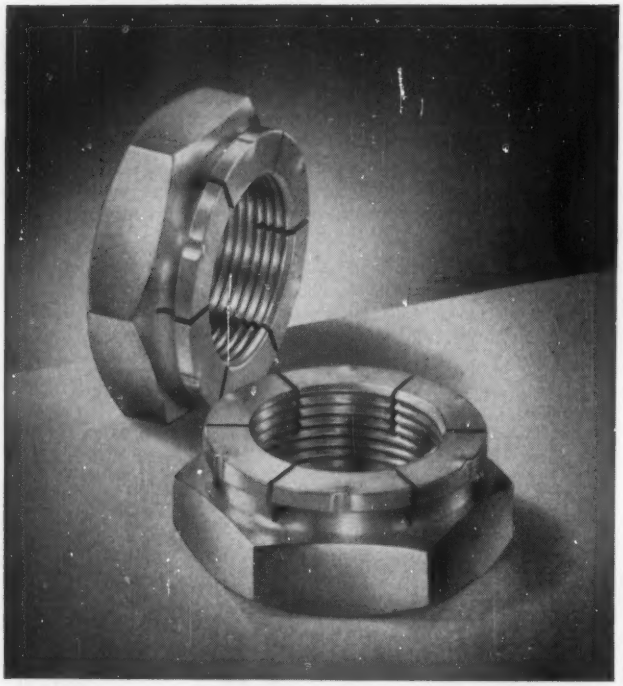
Two cams and one gear are cut simultaneously on a gasoline motor part. Center support fixture holds part in No. 4GS Gear Shaper.



Fixture for automatically loading and unloading automotive pinions on the No. 4GS Gear Shaper.

THE PRECISION LINE **Fellows** *Gear Production Equipment*

Flexloc thin nuts save space, weight and production time



Self-locking nuts are 30% lower and lighter; speed up assembly with hand or power tools

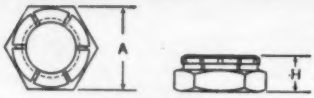
Self-locking FLEXLOC thin nuts are 30% lower than regular height locknuts of the same nominal diameter. They fit into spaces where regular height locknuts will not go. You can design lighter, more compact units with them.

Where you must reduce weight in a completed assembly, you can save by using shorter bolts with these lighter nuts. And you save production time. The length of engagement of mating threads is shorter: fewer revolutions of hand wrenches or power nut runners are needed to seat them.

FLEXLOC nuts are of 1-piece, all-metal construction. You can use a FLEXLOC fully seated as a locknut or at any point along a bolt as a stop nut. Once the threads in the resilient locking section are fully engaged, the FLEXLOC grips the mating threads with uniform locking torque wherever wrenching stops. Since there are no nonmetallic inserts to come out or deteriorate, the locking life of a FLEXLOC is virtually unlimited.

Your authorized industrial distributor stocks FLEXLOC nuts in a variety of sizes, materials and finishes. Consult him for details. Or write us for information about your special locknut problem. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

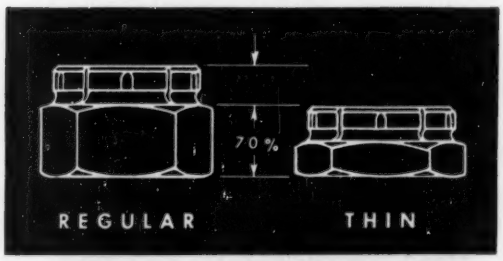
SPECIFICATIONS
FLEXLOC THIN NUTS



NATIONAL COARSE THREAD—U.S.S

SIZE	A INCHES	H INCHES	WIDTH ACROSS CORNERS	WEIGHT PER 1000 NUTS
6-32	.312	.125	.361	1.8
8-32	.344	.172	.397	2.8
10-24	.375	.172	.433	3.3
¼-20	.438	.203	.505	5.4
5/16-18	.563	.250	.649	11.6
3/8-16	.625	.265	.722	14.9
7/16-14	.750	.312	.866	24.9
½-13	.813	.312	.938	28.4
9/16-12	.875	.359	1.010	36.1
5/8-11	1.000	.391	1.155	54.1
¾-10	1.125	.406	1.299	69.2
⅞-9	1.312	.469	1.516	107.5
1-8	1.500	.563	1.732	171.6
NATIONAL FINE THREAD—S.A.E.				
6-40	.312	.125	.361	1.8
8-36	.344	.172	.397	2.8
10-32	.375	.172	.433	3.3
¼-28	.438	.203	.505	5.4
5/16-24	.500	.250	.577	8.7
3/8-24	.563	.266	.649	11.5
7/16-20	.625	.312	.722	14.9
½-20	.750	.312	.866	21.7
9/16-18	.875	.359	1.010	36.2
5/8-18	.938	.391	1.082	42.4
¾-16	1.063	.406	1.227	54.5
⅞-14	1.250	.469	1.443	84.6
1-14	1.438	.563	1.660	136.3
1 1/8-12*	1.625	.625	1.876	193.5
1 1/4-12*	1.813	.750	2.093	296.0
1 3/8-12*	2.000	.812	2.309	389.0
1 1/2-12*	2.187	.875	2.526	498.0

*Steel only (plain or cadmium plated) in stock sizes.



FLEXLOC thin nuts are 30% lower than regular height locknuts. There is a corresponding saving in weight. In sizes through 5/16 in., thin FLEXLOCS meet tensile strength requirements for regular height locknuts. FLEXLOC nuts can be made in the thin type because every thread, even those in the locking section, carries its full share of the load. There are no nonmetallic inserts to waste head space or weaken the structure of the nut.

Standard FLEXLOC self-locking thin nuts are available in plain or cadmium plated alloy steel, for use in temperatures to 550°F; in plain or silver plated corrosion resisting steel, for temperatures to 750°F; and in brass and aluminum, for temperatures to 250°F.

STANDARD PRESSED STEEL CO.

FLEXLOC® LOCKNUT DIVISION SPS

JENKINTOWN ■ PENNSYLVANIA

Simple • Versatile • Compact

NUMATICS

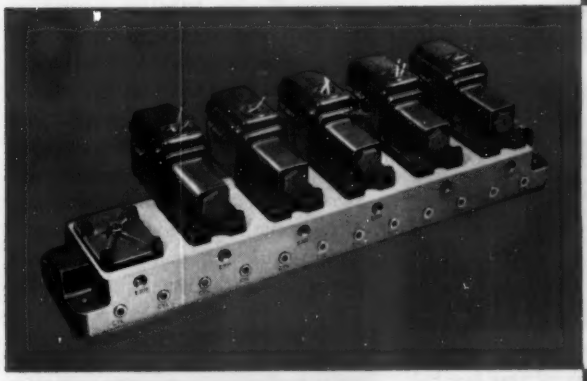
MULTIPLE MOUNT MANIFOLDS

YOU ASKED FOR IT!

Numatics research, engineering and production have come up with it—a new, simplified, streamlined series of manifolds for multiple mounting, piping and wiring solenoid-operated air valves. They're compactly built, quickly installed, readily accessible, easily maintained. They're available in ¼", ⅜", ½" and ¾" valve pipe sizes in from two to six stations—and all valve actions in Numatics SA Series may be mounted interchangeably on any manifold station. In a word, Numatics new manifolds provide the flexibility, efficiency and economy you've been looking for in a control system.

C SERIES MANIFOLD—

Designed to eliminate separate electrical pull boxes and the confusion of numerous conduit runs, Numatics Conduit Manifold may be used with either M or H Series air manifolds. A selection of from 3 to 6 stations is offered—and all valve actions, in ¼" and ⅜" pipe sizes, are interchangeably mountable on any station. Further, once assembled, the basic installation need never be disturbed, as individual access to any valve in the group is provided for by separate cover plates.

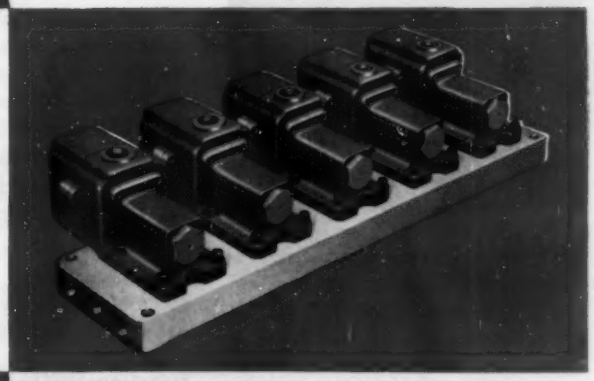


M SERIES MANIFOLD—

For the ultimate in piping flexibility, Numatics offers the Individual Exhaust Manifold Series. The common supply passage, running the length of the manifold, is threaded at both ends. Each exhaust port is threaded one side and bottom . . . allowing unit to be piped from any side or combination of sides. Available in three sizes . . . A for ¼" and ⅜" valves, B for ½" valves, C for ¾" valves—in a minimum of 2, a maximum of 6 stations.

H SERIES MANIFOLD—

Where it is desirable to have all exhausts manifolded into common exhaust chambers, use Numatics H Series Manifold. All exhaust ports join into two exhaust passages which run the length of the unit and parallel to the common supply passage. Exhaust and supply ports are threaded at both ends . . . cylinder ports are threaded in the bottom face, thus permitting piping from the bottom only. H Series manifolds are offered in ¼" and ⅜" sizes in from 3 to 6 stations.



FREE 16 page catalog containing descriptions, illustrations and complete specifications on Numatics' new manifolds, SA Series valves and control accessories. It's Catalog 5000A —send for your free copy today!

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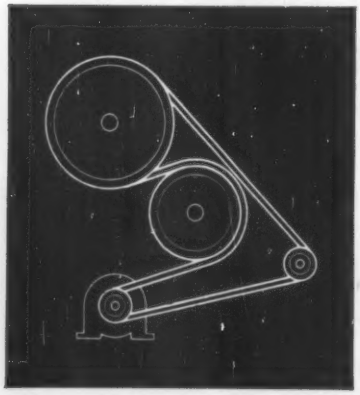
DEPT. MD

V-Belt Designer's Notebook

A special V-Belt Engineering Service to help you cope with 7 Drive Problems created by space-saving modern design

A checklist of V-belt drive designs which require specialized engineering. With a description of the compensating characteristics which can be built into special Dayton V-Belts. Sources: Case histories from the files of the Dayton Special V-Belt Engineering Service and "The Dayton Handbook of V-Belt Drive Design and Selection."

Here's a typical example of efficient, compact, modern design—an automatic washer with a Dayton V-Belt Drive.

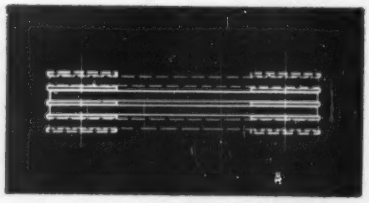


Note that it imposes three design requirements, (1) a torturous back bend (2) sub-diameter pulleys (3) a limited tension take-up area. Yet the design is efficient because Dayton V-Belt engineers developed a belt especially adapted to these three punishing conditions.

You'll find similar examples in machine tools, agricultural machinery and wherever drive space is limited. You've seen them yourself—the designs which dictate sheave misalignment, back-side idlers, underbelting; plus others which use V-Belts as a clutch and which impose excessive shock loads on the belt.

HERE ARE THE MAJOR CONDITIONS WHICH AFFECT V-BELT PERFORMANCE

Underbelting

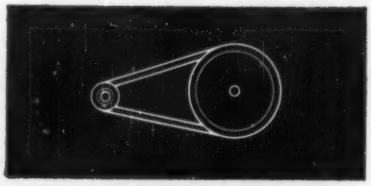


Underbelting is found where space is limited or as a result of very low belt speeds. It will cause belts to slip, run hot and wear out very quickly. A temporary cure, commonly employed, is to over-tension the belt — thus throwing excessive loads on the bearings.

The design requires a high capacity belt with extra-strength cords found in Dayton's Super-Thorobred series or, in difficult cases, belts with both a high coefficient of friction and extra strength like the raw-edge Dayton Cog-Belt.

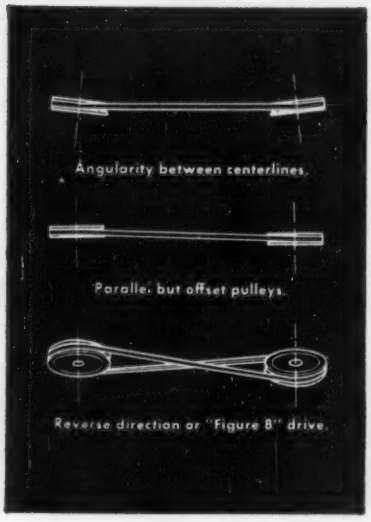
Sub-diameter sheaves

Belts driven by sub-diameter sheaves are inclined to succumb to accelerated flex failure. Tensioning problems are a usual result.



Sub-diameter sheaves require extremely flexible belts for satisfactory service. The required flexibility may be obtained by using thin V-Belts—where drive capacity is not high. When considerable capacity is required, Dayton Cog-Belts will give the most satisfactory performance. Their exclusive design permits exceptional flexibility. Die-cut raw edges provide high coefficient of friction, transmit maximum power from sub-diameter sheave arcs.

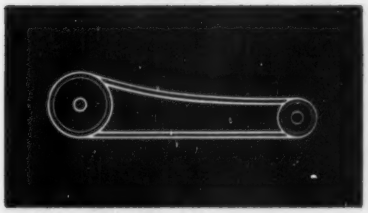
Misalignment



Misalignment causes uneven tension across the face of the belt—producing abnormal belt and pulley wear and uneven bearing loads.

A suitable approach is to use highly extensible cords of the latest synthetic fibers in the strength band of the V-belt. Dayton's Development Engineer can prescribe the material best suited to your needs.

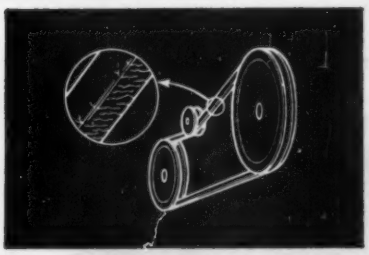
Fixed centers



Proper tension cannot be maintained with fixed centers or where center distance adjustment is inadequate. Without proper tension, belts slip and need frequent replacement.

Dayton V-Belts with low-stretch neutral-axis cords are best suited for applications with little or no provision for center distance adjustment. Still higher performance is gained if the belts have maximum cross-sectional stability which helps keep the belt from seating in the sheave groove.

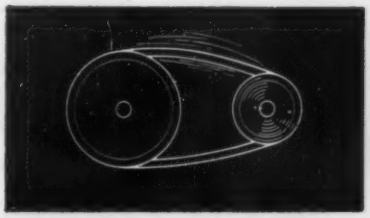
Back-side idlers



Cracks will appear on the under side of the belt, since back-side idlers force the belt to flex in a direction contrary to its construction. Use of spring-loaded back-side idlers may result in belt-snapping.

Where back-side idlers are used to provide tension take-up, they must never be smaller than the smallest pulley in the drive. Dayton V-Belts used in this case employ tension or stretchy type materials in the compression section and have a relocated neutral axis.

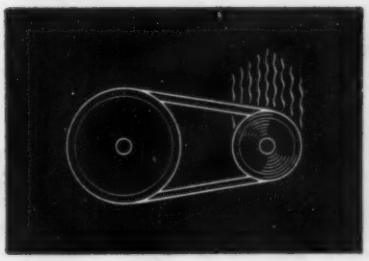
Excessive shock



Excessive shock can cause the belt to snap as well as promote bearing troubles and sheave misalignment.

Belts subject to excessive shock or heavy pulsation require strength band constructions which offer changeable ratios between stress and strain without taking a permanent stretch. Belts with soft cross sections — that will ride up and down in the groove — work well under shock as do wide angle belts. Any of these belts are available from Dayton.

Using as a clutch



V-Belts are ordinarily designed for constant loads and will burn when used as a clutch.

But, belts especially designed for use as a clutch will readily slip when a load is suddenly applied or released. Dayton cover stocks used here have a low coefficient of friction and high resistance to wear.

DAYTON'S SPECIAL V-BELT ENGINEERING SERVICE

Make use of Dayton's Special V-Belt Engineering Service when you encounter any of these designs. Your Dayton V-Belt design engineer is an expert who has devoted himself exclusively to V-Belt Drives. Your design may permit a minor modification which would adapt it to the use of low-cost standard V-Belts. Other standard Dayton V-Belts available for special applications are the Double-Angle V-Belt, the Double Cog-Belt, the Variable Speed Cog-Belt and the back-side idler V-Belt.

With one of the finest research and development laboratories in the industry, Dayton research engineers constantly advance V-Belt knowledge. They develop basic theory, prove the characteristics of the newest compositions and materials available to the rubber industry and test the performance of theoretical constructions. All of this acquired information is at your call when you need a special V-Belt.

Now, while your design is on the drawing board, is the time to call your Dayton V-Belt design engineer. He'll help you select the V-Belt which is tailored to your specific drive. The result — a compact, versatile design which meets all your minimum design requirements and one that will give its users years of trouble-free service.

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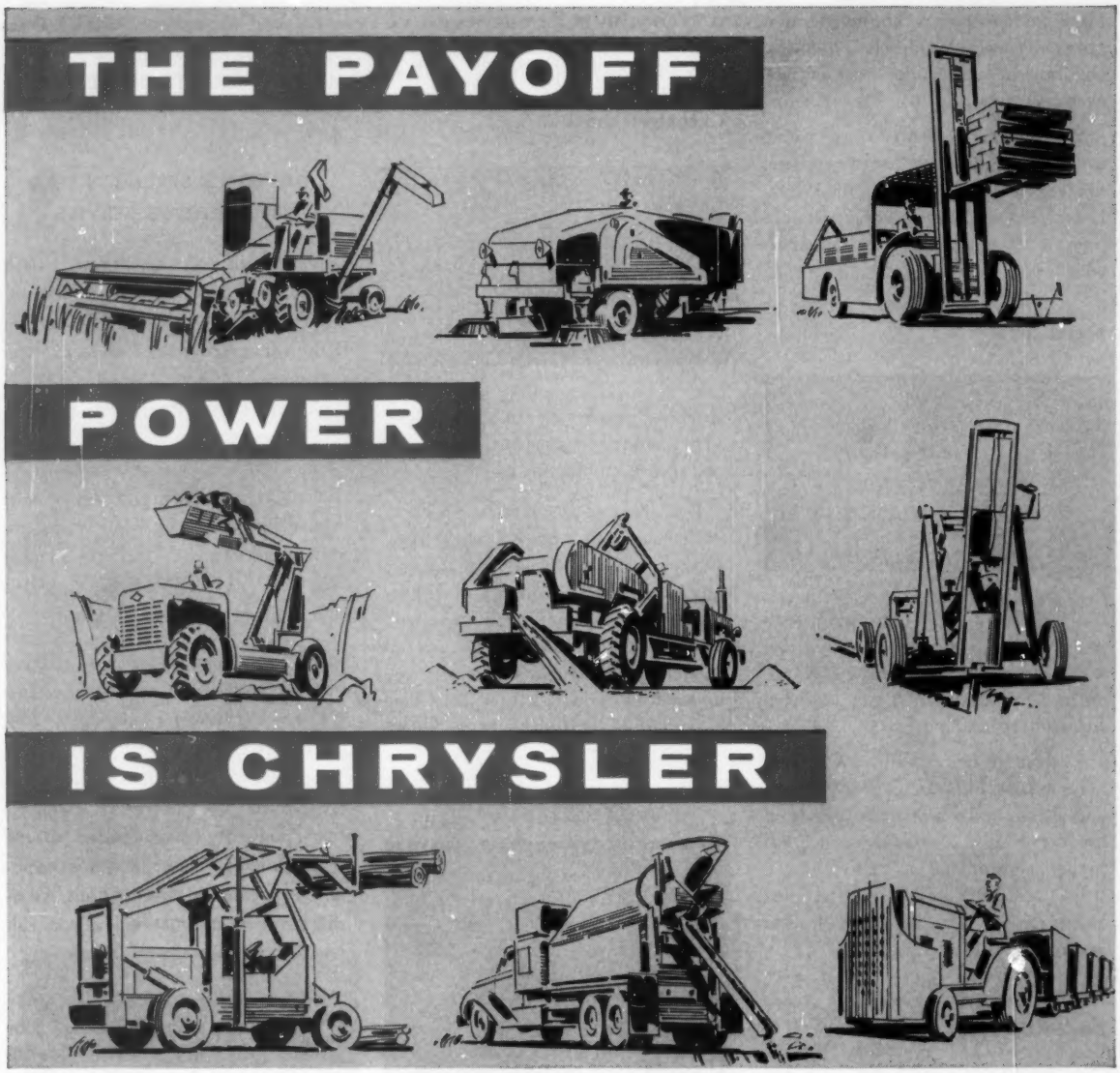
If you haven't received your copy of Dayton's authoritative Handbook of V-Belt Drive Design and Selection, write for it now. Just give us your name, title, and the address of your firm.

Circle 432 on page 19

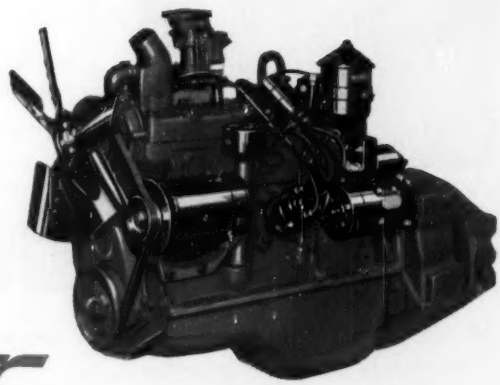
THE PAYOFF POWER IS CHRYSLER



In the oilfields of Texas and Oklahoma . . . in the timber country . . . farmlands . . . industrial areas . . . and on construction jobs large and small. Wherever big shouldered, hard driving power is required – there you'll find Chrysler Industrial Engines at work.

Look around. More and more manufacturers are powering with Chrysler when they build. More and more users are specifying Chrysler Power when they buy. Why? Because both have found that Chrysler produces more payoff power than any other industrial engine built today.

See a Chrysler Industrial Engine Dealer – listed in the yellow pages of your telephone book – or write for detailed information: **Dept. C-1, Industrial Engine Division, Chrysler Corporation, Detroit 31, Michigan.**



Chrysler

INDUSTRIAL ENGINES

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

Circle 433 on page 19

In heavy-duty drives . . . demand assurance of

permanent, accurate shaft alignment

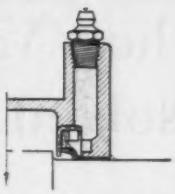
Sturdy Housing of heavy, close-grained gray iron provides rigid support of shafts. Designed so that all parts can be removed without disturbing base or draining oil.

It's yours... with these other "plus" performance features — in LINK-BELT Parallel Shaft Drives

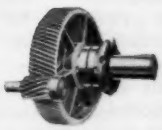
Under the shocks and overloads that are often imposed upon parallel shaft gear drives, rugged housing construction is compulsory if shaft alignment is to be maintained. That's why Link-Belt adds special reinforcement at points of greatest stress . . . has developed this design expressly for endurance in heavy-duty service.

Write for Book 2619 on this broad line with ratios to more than 300:1. Or get first-hand facts from your nearest Link-Belt office.

Ball and Roller Bearings are of ample size and capacity to withstand shock and overloading.



Grease-Lubricated Seals on all input and output shafts prevent entrance of dirt, water.



Precision Gears and Shafts are arranged to provide high reduction ratios in small space.

Automatic Splash Lubrication reliably supplies oil to all gears and bearings.

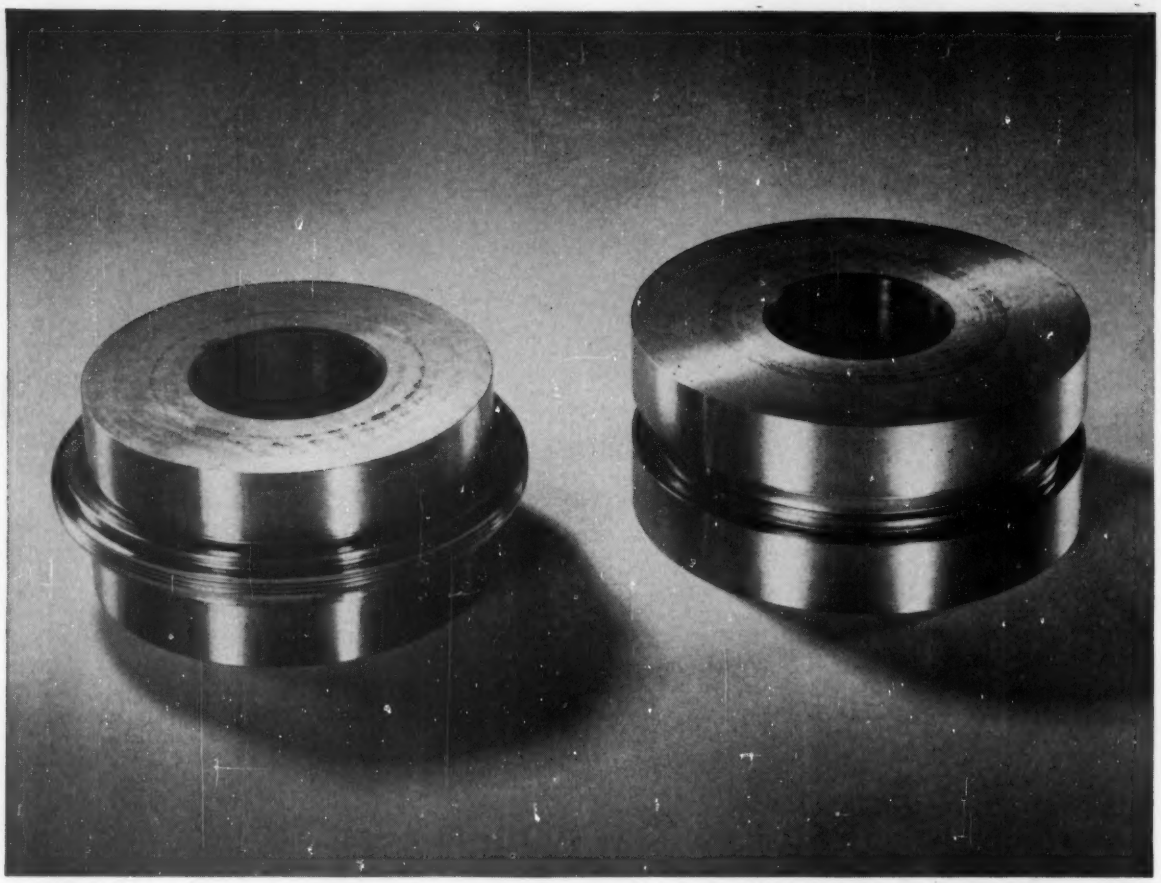
14,308

LINK-BELT

ENCLOSED DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

Circle 434 on page 19



how Vacuum Metals FERROVAC solved critical surface problem for Bausch & Lomb . . .

The jewelers' rolls Bausch & Lomb use to roll gold-alloy wire for eyeglass frames must be *mirror-smooth*. Rolls of conventional air-melted alloys just didn't work out economically. A normal amount of nonmetallic inclusions in the metal meant they had to be ground and reground, polished and repolished, before the surface was satisfactory. And even then, many rolls had to be scrapped when finishing uncovered inclusion pits.

The solution to this problem proved to be Vacuum Metals FERROVAC® Airdi 150. A better finish was obtained without any regrinding—and the number of scrapped rolls fell to zero. Here's why: Vacuum-melting removes the gases which create nonmetallic inclusions in the molten metal before they get into the product. This means cleaner metal, smoother surfaces. What's more, vacuum-melting improves fatigue, creep and impact strengths . . . reduces brittleness.

Vacuum-melted metals are the answer to jobs where surface is critical—like gauge blocks, plug and ring gauges, rolls for aluminum foil—as well as many other specially demanding applications. They're available in most grades and sizes, including special ferrous and non-ferrous alloys. Write now for a free analysis sheet on which to describe your application. It will help us both decide how vacuum-melted metals can serve you best. *Vacuum Metals Corporation, Division of Crucible Steel Company of America, P. O. Box 977, Syracuse 1, New York.*

VMC®

VACUUM METALS CORPORATION

Division of Crucible Steel Company of America

Helpful Data from
DE LAVAL

How to calculate the efficiency of worm gearing

The efficiency of worm gearing is determined by frictional losses at the tooth contact, bearings and oil seals plus losses from oil churning and windage. A formula for efficiency at the tooth contact may be developed from a consideration of the forces at the contact. Figure 1 shows these forces acting on a developed section of the worm thread. For simplicity the pressure angle has been assumed to be zero.

The coefficient of friction of the worm and gear is a function of the materials, finish, lubrication and rubbing speed. The latter is the relative speed between a point on the pitch surface of the gear and one on the pitch surface of the worm. The coefficient of friction varies very little at high rubbing speeds but rises with increasing rapidity as the speed drops below 500 fpm.

The efficiency formula developed in Figure 1 involves worm lead angle and the friction angle. Figure 2 provides a relationship between friction angle and rubbing speed based on tests made on accurately manufactured gearing consisting of hardened and ground worm and bronze gear operating in oil.

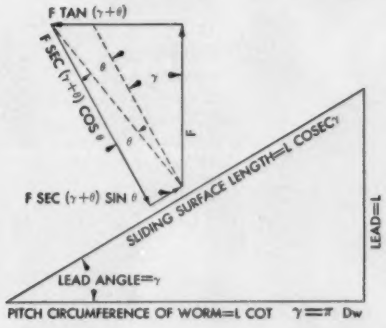
The formula for rubbing speed is:

$$V = \frac{262\ Dw \times \eta}{\cos \gamma}$$

where

V = Rubbing speed – feet per minute
Dw = Worm pitch diameter – inches
η = Worm speed – rpm
γ = Worm lead angle

FIGURE 1.
Development of equation for efficiency at contact between worm and gear



F=TANGENTIAL FORCE ACTING ON GEAR

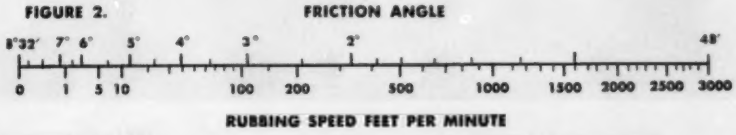
F TAN ($\gamma + \theta$) = TANGENTIAL FORCE APPLIED TO WORM

F SEC ($\gamma + \theta$) COS θ = FORCE NORMAL TO CONTACT SURFACE

F SEC ($\gamma + \theta$) SIN θ = FRICTIONAL FORCE

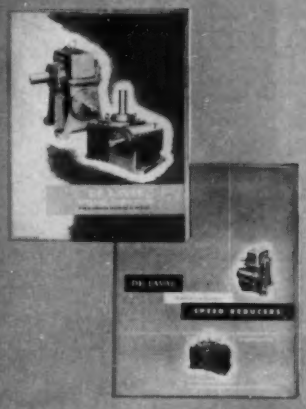
$$\text{EFFICIENCY} = \frac{\text{WORK REALIZED}}{\text{WORK APPLIED}} = \frac{L \times F}{L \cot \gamma \times F \tan (\gamma+\theta)} = \frac{\tan \gamma}{\tan (\gamma+\theta)}$$

FIGURE 2.



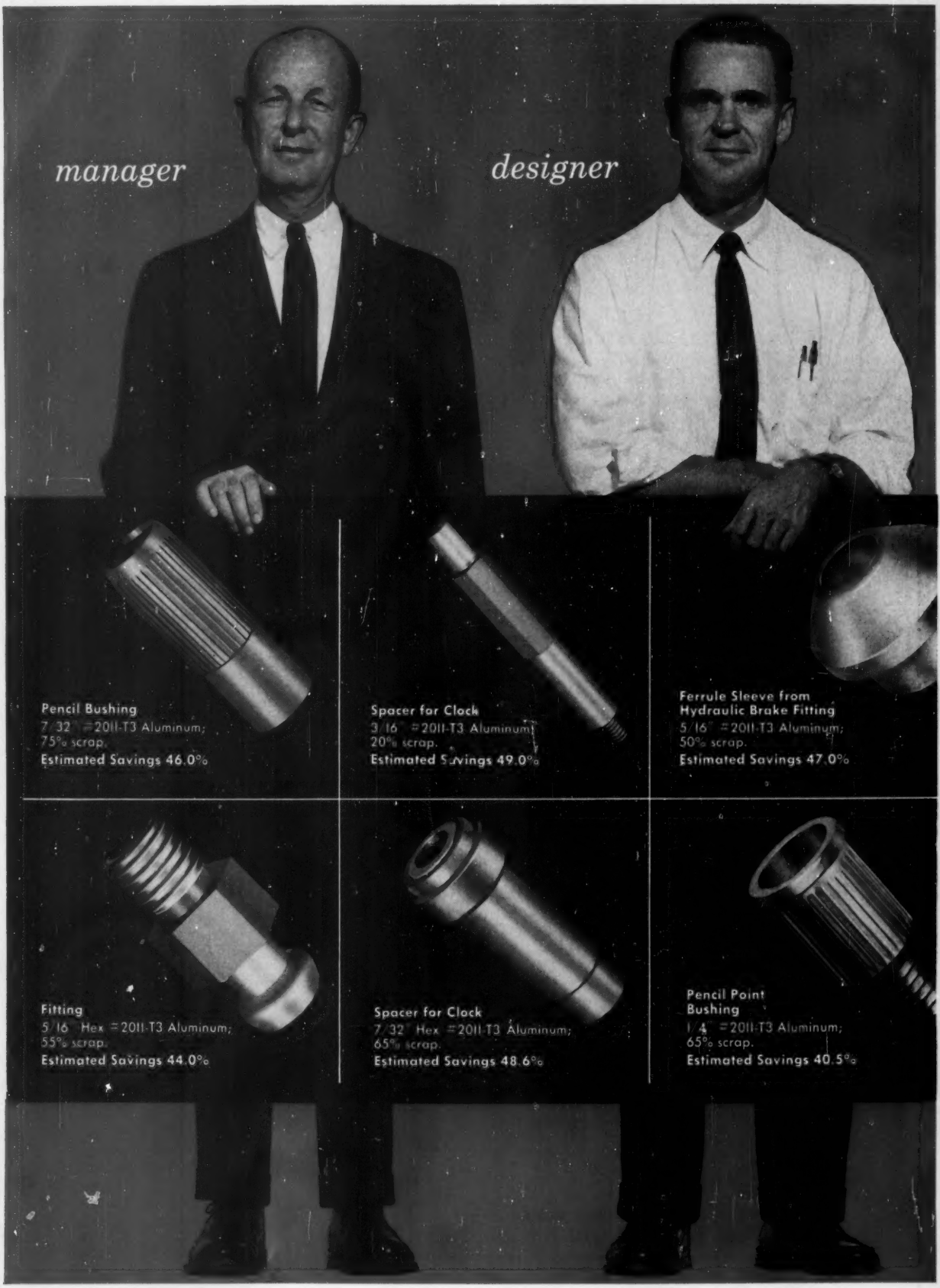
DE LAVAL Worm Gear Speed Reducers Offer Efficiencies to 96%

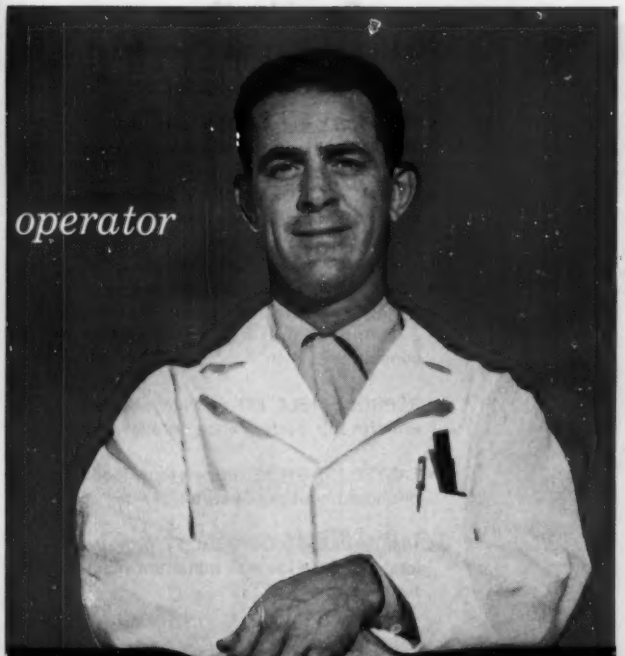
Ruggedly built for long efficient service De Laval speed reducers are made in horizontal and vertical single reduction units in ratios of 3:1 to 100:1. They are also available in double horizontal and vertical double reduction units as well as in helical-worm and double-worm design. Ratios from 37.8:1 up to 6400:1.

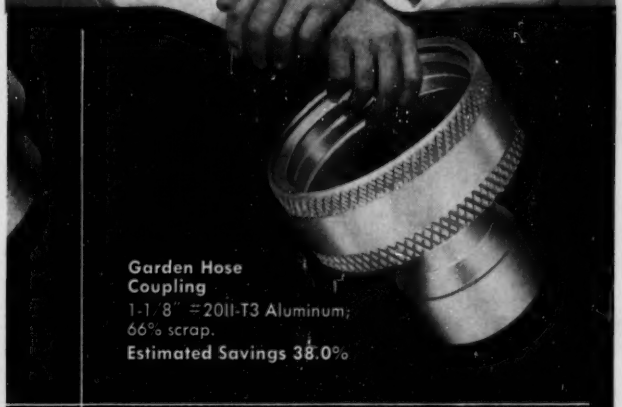


Write for your copies of Catalogs G-WBV and G-WWH to De Laval Steam Turbine Company, Trenton 2, New Jersey.

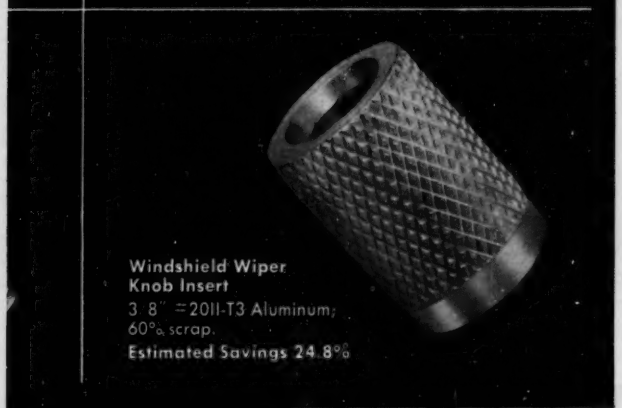
Please direct inquiries to advertiser, mentioning MACHINE DESIGN


manager
designer
Pencil Bushing
7/32" ⌀2011-T3 Aluminum;
75% scrap.
Estimated Savings 46.0%
Spacer for Clock
3/16" ⌀2011-T3 Aluminum;
20% scrap.
Estimated Savings 49.0%
Ferrule Sleeve from
Hydraulic Brake Fitting
5/16" ⌀2011-T3 Aluminum;
50% scrap.
Estimated Savings 47.0%
Fitting
5/16" Hex ⌀2011-T3 Aluminum;
55% scrap.
Estimated Savings 44.0%
Spacer for Clock
7/32" Hex ⌀2011-T3 Aluminum;
65% scrap.
Estimated Savings 48.6%
Pencil Point
Bushing
1/4" ⌀2011-T3 Aluminum;
65% scrap.
Estimated Savings 40.5%





Garden Hose Coupling
1-1/8" =2011-T3 Aluminum; 66% scrap.
Estimated Savings 38.0%



Windshield Wiper Knob Insert
3/8" =2011-T3 Aluminum; 60% scrap.
Estimated Savings 24.8%

ASK ALL THREE

why these eight screw machine parts were converted from brass to Kaiser Aluminum...

Operators say "easy to machine"...

Designers say "exceeds requirements"...

Management says "saves "saves money."

Let us assist you in designing lower cost screw machine parts with...

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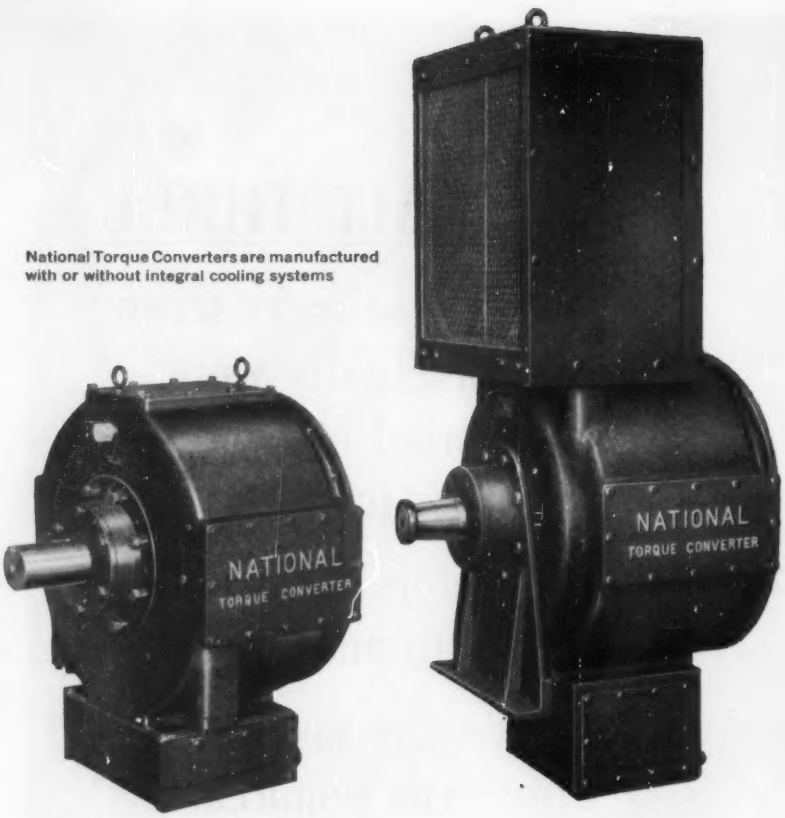
For complete information and expert assistance, call one of our many distributors, or look for our local number in your classified telephone directory.

Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Illinois; *Executive Office,* Kaiser Bldg., Oakland 12, California.

See "THE KAISER ALUMINUM HOUR." Alternate Tuesdays, NBC Network. Consult your local TV listing.

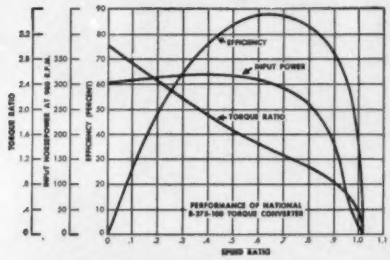
National Torque Converters are manufactured with or without integral cooling systems



Consider these National Torque Converter features

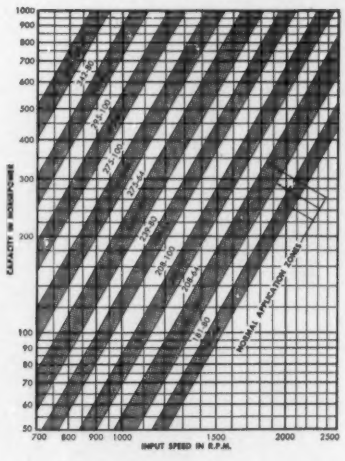
- SIMPLICITY OF DESIGN for ease of installation, operation and maintenance
- FULL RANGE OF CIRCUIT SIZES permits exact matching to prime movers of 100 to 1000 horsepower
- TOP PERFORMANCE enables engine or motor to operate at its optimum speed . . . deliver maximum horsepower constantly
- REPRODUCIBLE EFFICIENCY assures uniform top performance on every job
- FASTER JOB CYCLES means more loads per equipment per operator per day
- UNSURPASSED DURABILITY provides longer service life with minimum maintenance

Typical performance curves



Curve shows torque-speed ratio for series B-275-100 National Torque Converter. Performance Curves of all six sizes and 17 hydraulic circuits covering the 100 to 1000 horsepower range are available on request.

National Torque Converter Capacity Chart



Plan now to DESIGN with National Torque Converters

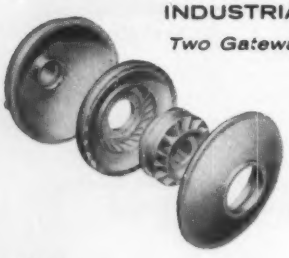
The simplicity of design of National Single-Stage Torque Converters permits exact matching of torque converter to prime movers of 100 to 1000 horsepower. Installation is simple and easy on stationary as well as mobile equipment. When matched to your prime mover, the National Torque Converter assures uniform top performance on every job. It will give your equipment a constant flow of smooth, steady power over a wide range of loads. It permits quicker starting and faster acceleration of loads, with no lugging or stalling of the prime mover. The torque converter absorbs the shock of sudden overloads, permitting the prime mover to operate at all times at governed or optimum speed.

Our engineers will gladly discuss the application of National Torque Converters to your equipment and help you select exact size and torque capacity. Why not call on them? Or write for Bulletin No. 468.

THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.



Pace-setters in the progress of industrial power transmission

Circle 437 on page 19

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern equipment

Sanitation . . . easy maintenance . . . inherent cleanliness . . . ready adaptability to a host of different shapes and forms—these are a few of the reasons why more and more designers of food processing, dairy and beverage equipment specify stainless steel.

You'll find it in tubing, tanks, bulk coolers, autoclaves and dozens of other vital pieces of equipment in many different industries.

Stainless steel's superior resistance to corrosion . . . ready availability in scores of work-saving standard shapes adaptable to many needs . . . ease of machining, forming, joining and casting combine to give equipment producers greater freedom of design.

For more information about stainless steel and its growing effect on equipment design and selling problems, see your stainless steel supplier or write ELECTROMET—leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steels.

ELECTRO METALLURGICAL COMPANY
A Division of
Union Carbide and Carbon Corporation
30 E. 42nd Street UCC New York 17, N. Y.
METALS DO MORE ALL THE TIME . . . THANKS TO ALLOYS

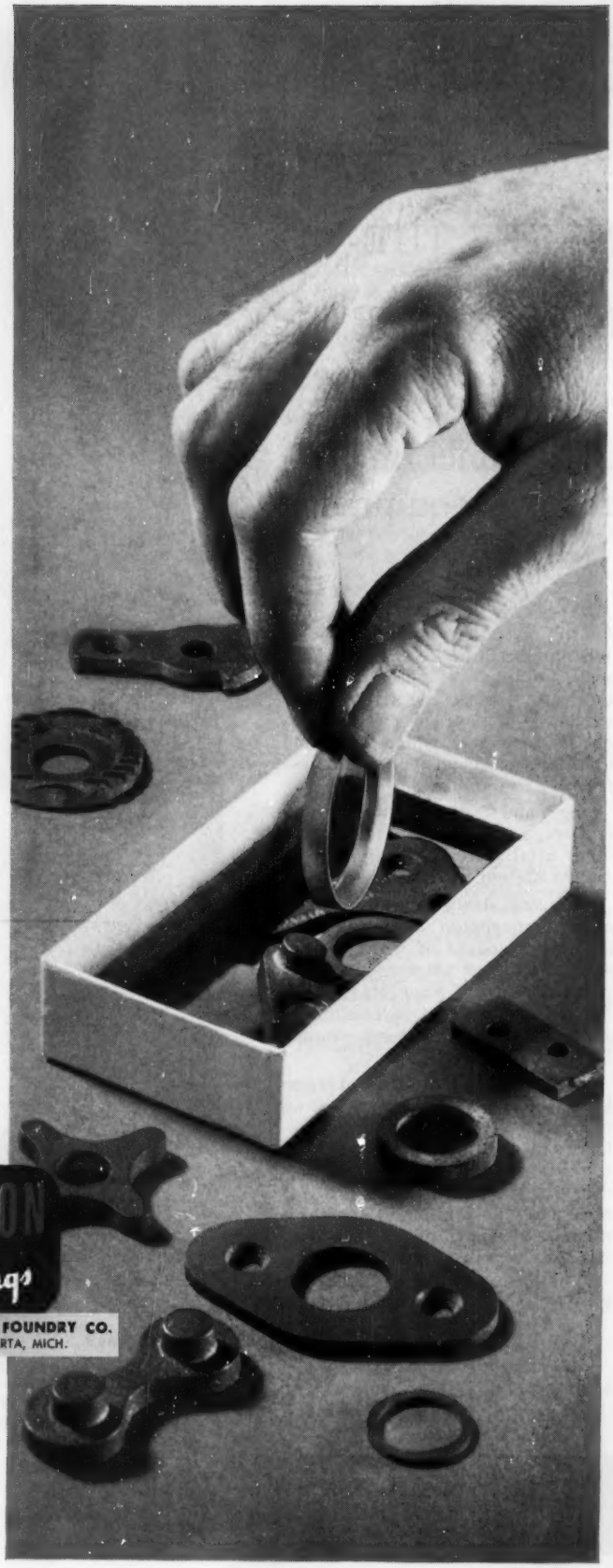
Electromet
TRADE-MARK

Sanitation is a powerful selling tool in the beverage, food processing and dairy fields. That's why the use of sanitary, easy-to-clean stainless steel is growing so fast.

Circle 438 on page 19

Get this free sample kit of precision castings

Here are the kind of precision castings Muskegon's Sparta Foundry can produce at surprisingly low cost. These small parts are actual samples of the workmanship and materials available from the world's largest piston ring casting foundry. Close examination will show that some of these castings are completely finished—surface ground, deburred, drilled, reamed and tapped—ready for immediate installation. Others are partially finished—with cast-in holes, recesses and projections. These parts typify how Sparta can reduce or completely eliminate your finishing and machining operation—with width tolerances held to within plus or minus .001"; flatness and surface finishes to your specifications. Write Sparta for your kit of miniature sample castings now!



Since 1921... The engine builders' source!

MUSKEGON Piston Rings

SPARTA FOUNDRY CO.
SPARTA, MICH.

AFFILIATE:

Rotary Seal Division, manufacturers of mechanical seals for rotating shafts. Plants at Chicago, Ill. and Sparta, Mich.

Circle 439 on page 19

USING

DU PONT ELASTOMERS

neoprene · Hypalon®

in design

New NEOPRENE closure strip weatherproofs corrugated roofing and siding

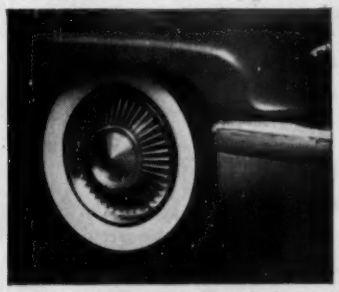
Tire sidewall of HYPALON® stays white, resists sunlight, ozone

A leading tire manufacturer has greatly improved the appearance and performance of whitewall tires by using a special rubber compound which includes a substantial amount of HYPALON, Du Pont's new synthetic rubber. Road tests in the Los Angeles area show that the inclusion of HYPALON keeps the sidewall from cracking and becoming discolored.

Chief reason for this success is the outdoor stability of HYPALON. Minute traces of ozone in the air are the primary cause of whitewall deterioration, but HYPALON is *completely unaffected by ozone*. It also withstands sunlight, weathering and discoloration far better than other kinds of rubber.

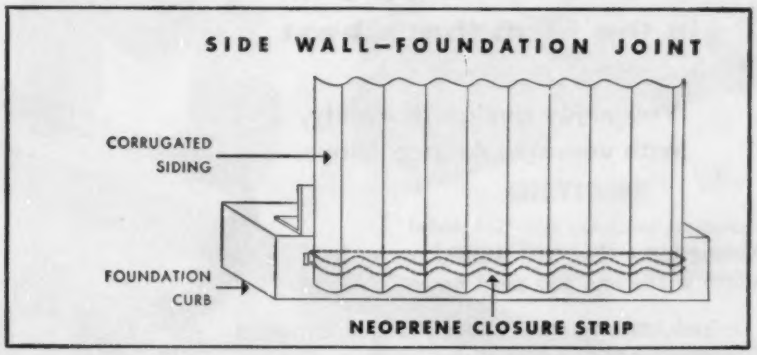
Idea for extra-long service

HYPALON also has many other properties of interest to designers. It shows unusual resistance to hardening at elevated temperatures (250°-350°F.) and has excellent resistance to solvents and chemicals, including strong oxidizing agents. These properties make HYPALON a wise choice for use in many industrial products, such as gaskets, molded parts, diaphragms, belt, hose—any resilient product that must give long cost-saving service where service conditions are severe. Just clip coupon for more information about HYPALON.



Lasting whiteness for sidewalls is now a reality with HYPALON. This versatile synthetic rubber can also be compounded in an unlimited range of light-fast colors.

Circle 440 on page 19



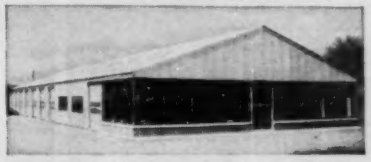
(Above) Diagram shows position of neoprene closure strip on side wall. (Left) Close-up shows manner of bolting neoprene strip to flashing section.

Elastic strip withstands temperature extremes... eliminates caulking

A new neoprene closure strip has been developed which, according to the manufacturer, will solve the problem of weatherproofing corrugated roofing and siding. Only an inch wide, this non-porous closed-cell neoprene closure strip is die-cut to fit corrugations, forming a snug seal. Neoprene's long service life assures lasting protection for a building's exterior from dust, dirt, water and air—at minimum maintenance.

The closure strips are installed on roofing under the aprons of ridge roll and under flashing sections at roof junctions and side walls. They're fastened at the same time as the corrugated sheeting. No separate caulking is required.

Neoprene's elasticity and lasting resistance to weathering, temperature extremes and aging are vital to the success of the closure design. The strip *stays* elastic, won't become brittle and then crack in cold weather or become soft and sticky in hot weather. You may find just the properties your designs need in neoprene, Du Pont's versatile synthetic rubber. For more information, just clip the coupon.



Hundreds of feet of neoprene closure stripping are used at roof, side wall, window and door junctures of this typical building.

DU PONT
REG. U. S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

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☐ Please add my name to the mailing list for your free publication, "The Elastomers Notebook."

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AMPCO — ONE-SOURCE SERVICE FROM RAW MATERIAL TO FINISHED PRODUCT

Does your sketch suggest a copper-base alloy?...

You name it...

Ampco can supply it, in the form that's best

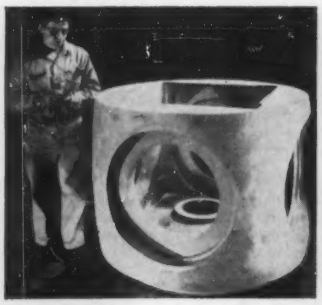
You enjoy design flexibility, with versatile Ampco alloys

Among more than 100 Ampco copper-base alloys is the one you need for

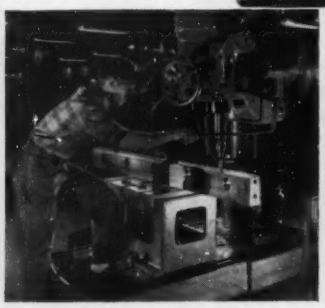
— resistance to wear, impact, fatigue, corrosion
— excellent bearing qualities
— retention of physical characteristics at temperatures from 600°F down to –400°F.

And equally important, you can select the best, most economical form of production — sand casting, centrifugal casting, shell mold, precision casting, forging, fabrication, extrusion, sheet, plate.

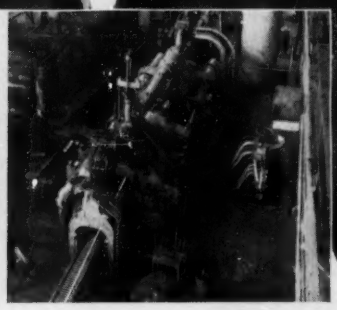
Call in your Ampco field engineer.
Write for Bulletin 33.



Sand castings in any size up to 14,000 pounds — and *centrifugal castings* up to five tons—are produced in Ampco foundries.



Ampco's one-source service includes production-run machining of copper-base alloys to quality standards of the aircraft industry.



2,275-ton hydraulic press in Ampco's modern, laboratory-controlled mill for extruding rods, bars, hollow rounds, and shapes.

D-60

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SHELL-MOULDED CASTINGS

CENTRIFUGAL CASTINGS

EXTRUSIONS

SAND CASTINGS

FABRICATIONS

SHEET AND PLATE

MACHINED PARTS

FORGINGS

CAST-TO-SIZE CASTINGS

Circle 441 on page 19

Circle 442 on page 19→

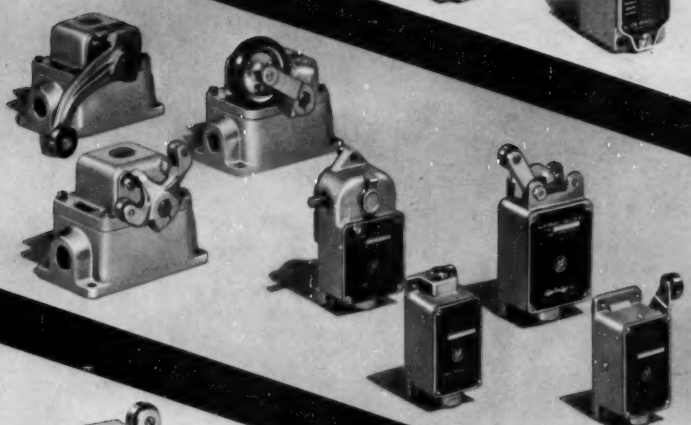
Need a Limit Switch?

WHAT'LL YOU HAVE?

Here are samples of A-B quality limit switches—a line so complete it will satisfy your every requirement!

OILTIGHT

Bulletin 802T—For high-speed production machines. Sealed to protect the switch against oil and coolants.



GENERAL PURPOSE

Bulletin 801—Standard or heavy-duty rating, with roller, push type, or fork lever action, and slow or snap action contacts.

Bulletin 803 Cam Limit Switch used on rotating machines to open and close circuits at any desired angular position.

PRECISION

Bulletin 802—For applications where mounting space is small and operating motion is measured in thousandths of an inch.

1-57-MR

ALLEN-BRADLEY

QUALITY

MOTOR CONTROL

A-B Quality

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

PILOT CONTROLS?

Yes...Allen-Bradley covers the field!

No matter what your needs for pilot control devices may be . . . refer to the new Allen-Bradley "handy" catalog . . . you will usually find what you are looking for. If not, please write Milwaukee, or contact your nearest Allen-Bradley representative.

All pilot controls are made to Allen-Bradley standards of quality. All of them have silver alloy contacts that require no service attention. You'll find it saves service time and money to specify Allen-Bradley.

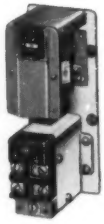
PHASE FAILURE AND PHASE REVERSAL RELAYS
BULLETIN 812
Style A disconnects motor if one phase of power circuit fails. Style B protects against phase reversal, as well.

OILTIGHT PUSH BUTTON STATIONS
BULLETIN 800T
For machine tool applications, to keep oil away from the contacts. Available in flush, surface, or pendant mounting.

PRESSURE CONTROLS
BULLETIN 836
For noncorrosive liquids, vapors, gases, from 30 in. of vacuum to 700 psi. Accurate, rugged, compact, and attractive appearing.

PLUGGING SWITCHES
BULLETIN 808P
Used with a simple reversing switch, it provides quick, automatic stopping of machines driven by squirrel cage motors.

TIMING RELAYS
BULLETIN 849
A reliable and accurate pneumatic timer with a range of 1/6 to 180 seconds. Many arrangements. Motor driven, electronic and oil dashpot timers also available.



TEMPERATURE CONTROLS
BULLETIN 837
For temperatures from −45°F to 440°F. Metal bellows operates snap action precision switch with pure silver contacts.

FOOT SWITCHES
BULLETIN 805
For operating punch presses, riveting, welding, and many other machines. Switch has snap acting, normally open and normally closed silver alloy contacts.

ZERO SPEED SWITCHES
BULLETIN 808
A plugging switch that brings squirrel cage motors to zero speed quickly, without any reversal of direction.

FLOAT SWITCHES
BULLETIN 840
Provide automatic control for motors operating tank or sump pumps.

PRESSURE SWITCHES
BULLETIN 830
For domestic water pumps, and commercial and industrial air compressors.

ROTARY SWITCHES
BULLETIN 806
Cam operated switches for the selection or transfer of various control circuits. Silver alloy contacts.

1-57-MR

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ALLEN-BRADLEY

MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
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Send for the new 7th Edition of the Allen-Bradley Handy Catalog. It is a veritable encyclopedia of reliable motor control.

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The RIGHT solution can save you money

. . . and chances are, Aetna can provide it. Many of the production and application problems of parts which are troublesome to you today, may have already been successfully studied and resolved by our design and application engineers. From hundreds of case histories they can give you valuable counsel—help you make certain that the vital parts that go into your products will provide the dimensional accuracy and stability so essential for sustained peak efficiency and longest life expectancy.

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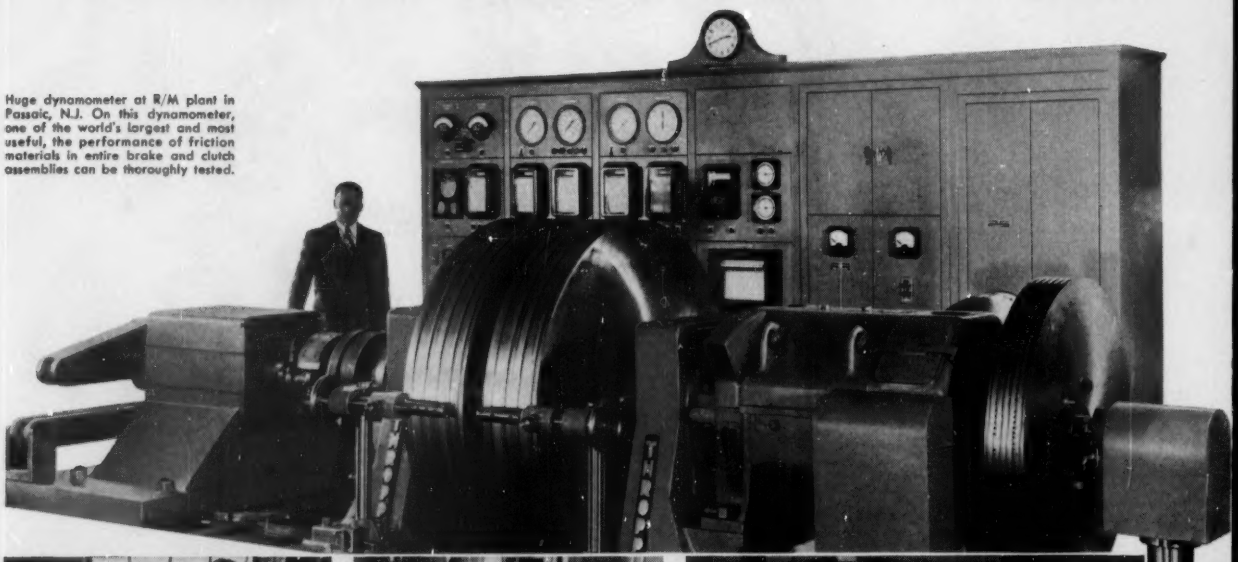
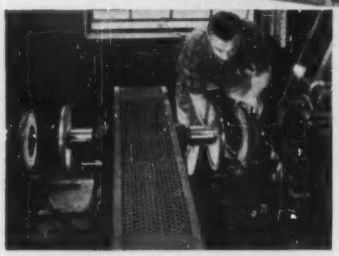
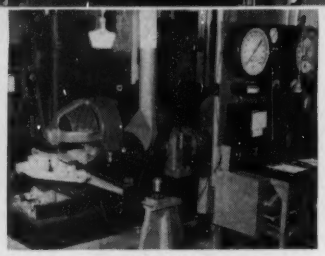
CALL ON R/M ENGINEERING SERVICE



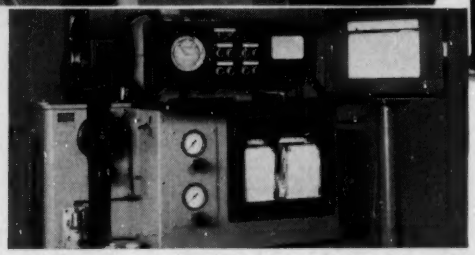
Huge dynamometer at R/M plant in Passaic, N.J. On this dynamometer, one of the world's largest and most useful, the performance of friction materials in entire brake and clutch assemblies can be thoroughly tested.



Two clutch tests can be performed simultaneously on this Long clutch machine at the R/M plant in Manheim. Friction and wear characteristics are tested continuously.



Aircraft landing and takeoff conditions are approximated on this heavy duty inertia dynamometer in the R/M plant at Bridgeport, Conn.



On R/M dynamometers a special Uni-Tork valve invented by R/M subjects brakes to a uniform rate of deceleration and helps produce test data more successfully related to field conditions than possible heretofore.

LAB AND FIELD TESTING SOLVES FRICTION PROBLEMS YOU MAY BE FACING NOW

The one sure way to learn how friction materials will perform in new applications is to test them—in the laboratory or in the field—and see. That's why Raybestos-Manhattan, world's leading maker of friction materials of all types, has the world's most complete, most adaptable testing facilities.

R/M testing equipment ranges from comparatively simple machines to giant inertia dynamometers, including one of the biggest ever made.

Much of this testing equipment was actually designed by Raybestos-Manhattan. And with it, the behavior of friction materials in applications ranging all the way from heavy duty railroad brakes to tiny fishing reel drags can be thoroughly and accurately explored for you by R/M engineers.

Remember, unlike any other manufacturer, R/M works with *all* kinds of friction materials—from woven and molded asbestos to cork-cellulose and sintered metal—and tests all kinds. As a result, R/M has acquired a wealth of knowledge about friction material performance that could solve problems *you* may be facing.

If you are working with friction materials, call in an R/M representative now. The complete facilities of R/M's seven great plants, with their research and testing laboratories, are as near as your telephone.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

FOR HELP IN SOLVING YOUR PROBLEMS

R/M FABRIC PISTON CUPS...

quality where it counts

If you want top performance in hydraulic and pneumatic applications, specify R/M Fabric Piston Cups. Here's why: precision molding produces dimensional uniformity and completely effective sealing; polymer-saturated fabric prevents internal destruction from wicking action, resists ply delamination. Furthermore, careful quality control assures consistent hardness and strict adherence to industry standard sizes.

The full R/M line includes packings and gasket sheets for use against gases, water, steam, oil, chemicals, solvents and food products. Feel free to call on R/M's specialized engineering service, if you have a problem involving any of these materials or products.

For booklet shown, or other data, write, phone or wire:

PACKING DIVISION
Raybestos-Manhattan, Inc.
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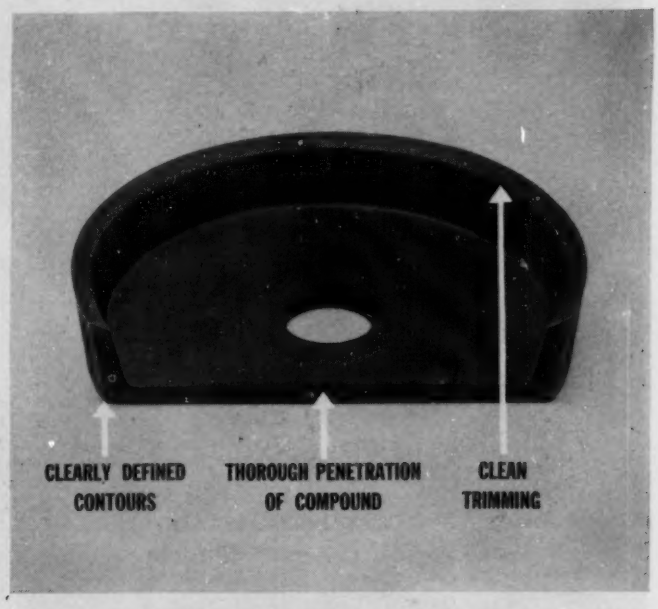

R/M ENDLESS BELT

Outlasts 3 to 10 Ordinary Belts

Only *one* take-up in over 3 years of 24 hour daily service "proved" Condor Whipcord Endless Belt on a pulp beater drive . . . and it can do the same for the equipment you design! Endless wound, sealed-in cord construction offers exceptional advantages in drives with short centers, small take-up, small pulleys, reverse bends, high speeds, or heavy loads at high tensions.

Condor Endless Belts are unaffected by moisture and atmospheric changes, and with exclusive "Extensible Tip" cover splice and rubber rivets they have outlasted 3 to 10 ordinary belts on many drives. If your design calls for endless transmission belts—or conveyor belts, V-belts, hose, molded rubber products—let an R/M industrial rubber specialist work with you.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
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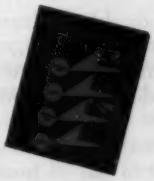

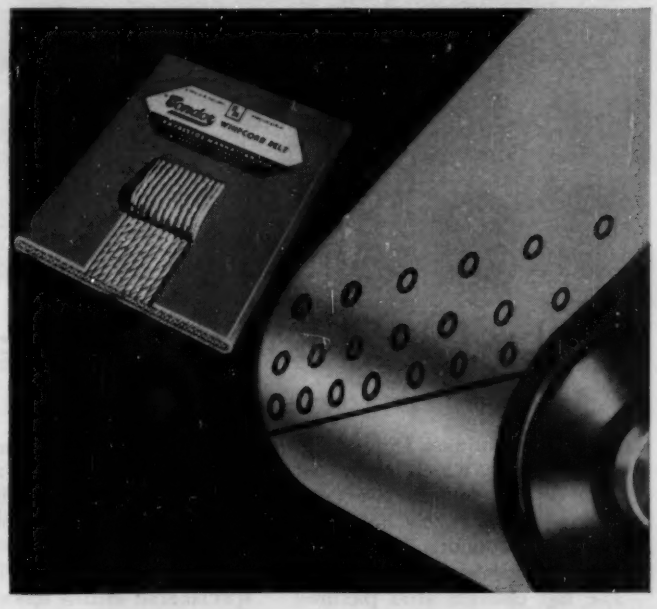

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FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

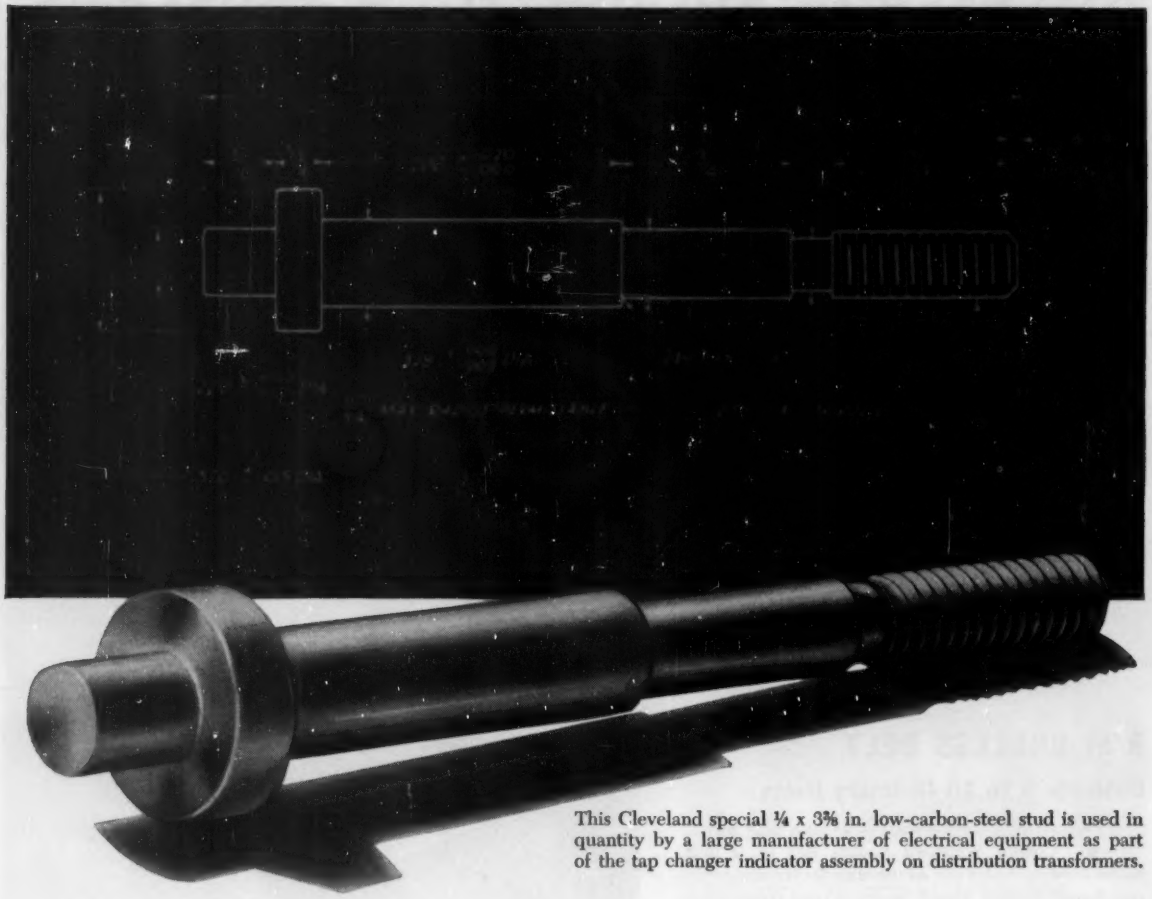
Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M

Circle 444 on page 19

CLEVELAND SPECIAL HEADED AND THREADED PRODUCTS



This Cleveland special ¼ x 3⅜ in. low-carbon-steel stud is used in quantity by a large manufacturer of electrical equipment as part of the tap changer indicator assembly on distribution transformers.

Cost of special collar stud is cut 20% by Cleveland's cold forming techniques

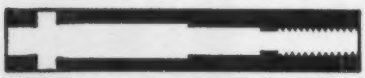
The famous Kaufman Double Extrusion Process which turns out millions of Cleveland precision cap screws yearly is highly adaptable to low-cost production of your fastener-type specials.

The tap changer stud pictured above is typical. Used by a well-known electrical equipment manufacturer, it was previously cut from bar stock. The special head, double shoulders, and groove above the threads meant numerous machining operations and considerable scrap.

Cleveland now cold forms this special stud at 20% less cost to the customer, while holding the specified .005 in. tolerance. And the part is stronger. In the head, threads and fillets, grain flow is symmetrical and unbroken. In addition, the forging action of the Kaufman process toughens surface metal while leaving the core ductile. Both fatigue resistance and tensile strength are thus increased.

We are regularly cold forming close-tolerance specials—many with unusual or extreme upsets—in large quantities. So whether your part is simple or complex, it will pay you to check with Cleveland, particularly at the design stage. There is an excellent chance that through cold forming we can cut the cost and improve the physical properties of the part you have in mind.

♦ ♦ ♦



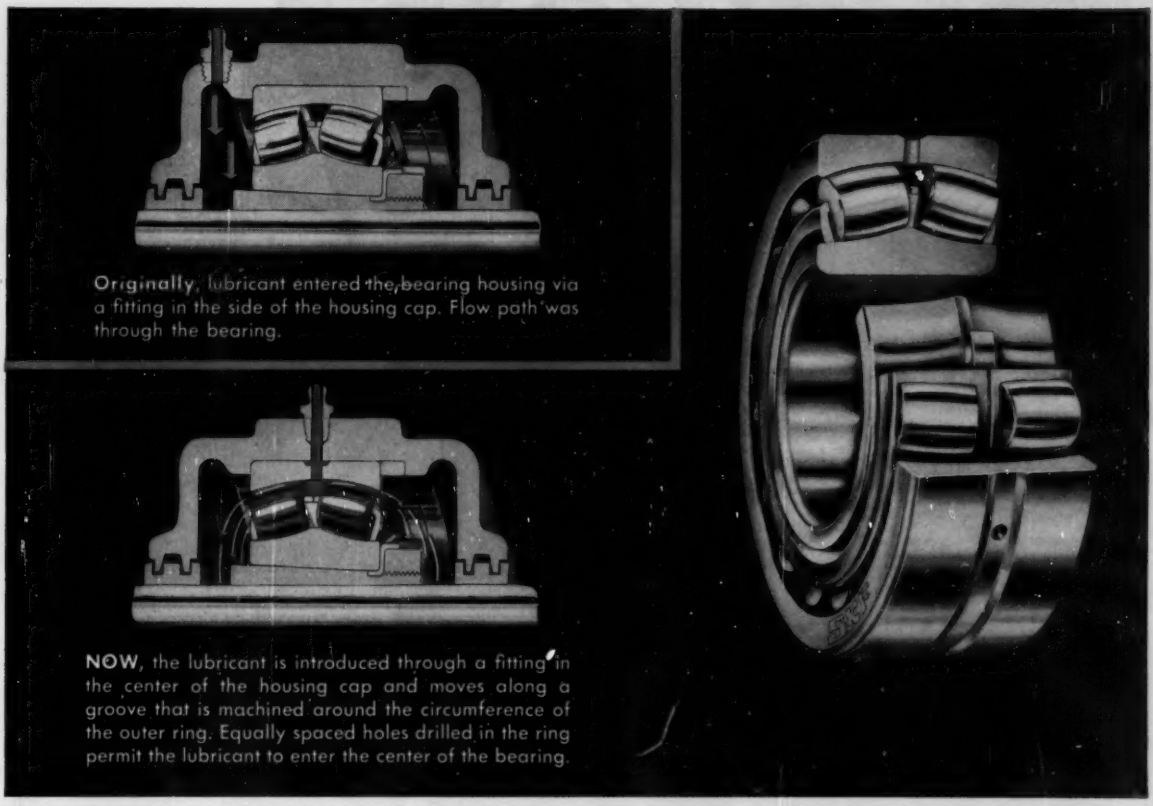
Black area represents metal that had to be cut away when stud was produced by machining. In the Cleveland cold forming process almost all the metal in the working slug is present in the finished part. The customer saves the difference.

Write for a copy of our folder "Specials by Specialists"

THE CLEVELAND CAP SCREW COMPANY
4444-6 Lee Road, Cleveland 28, Ohio

At No Extra Charge ...A MAJOR IMPROVEMENT

IN LUBRICATING SPHERICAL ROLLER BEARINGS


Originally, lubricant entered the bearing housing via a fitting in the side of the housing cap. Flow path was through the bearing.
NOW, the lubricant is introduced through a fitting in the center of the housing cap and moves along a groove that is machined around the circumference of the outer ring. Equally spaced holes drilled in the ring permit the lubricant to enter the center of the bearing.

Nobody but SKF Offers This to You on Spherical Roller Bearings

Once again **SKF** offers another important innovation in spherical roller bearing design. Available in spherical roller bearings 140 mm (5.5118") O.D. and larger, this feature represents a still further improvement to the proven **SKF** Type "C" Spherical Roller Bearing.

The new design allows the lubricant to enter at the *center* of the bearing and move outwardly – completely covering all working surfaces. Old lubricant is flushed away from the bearing and, with it, any abrasive dust, dirt, moisture, or other impurities.

You can use this improved bearing in your existing housings simply by moving the lubrication fitting to the center.

Here again is an example of how **SKF** helps you to obtain longer bearing life, at no added cost. Send for Bulletin No. 443 for complete details. 7751

EVERY TYPE—EVERY USE

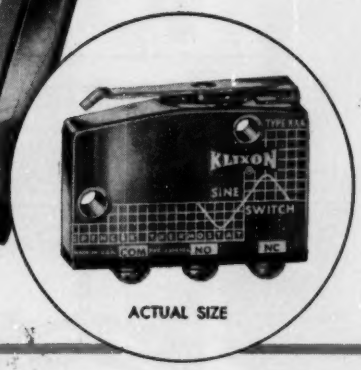
SKF®

Ball Bearings
Cylindrical Roller Bearings
Spherical Roller Bearings
Tapered Roller Bearings ("Tyson")

*Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

3X cut-away view of KLIXON KX4 Sine Switch



ACTUAL SIZE

Get precision switching completely free from environmental conditions

...with the KLIXON KX4 Sine Switch

Here's a small precision switch especially designed for use in aircraft and guided missiles, jet engine speed and fuel controls, signalling devices and precision instrumentation, chemical and packaging machinery, and industrial equipment.

KLIXON KX4 Sine Switches are sealed in an extra strong steel case designed to withstand heavy impact and compression loads. True hermetic sealing is achieved with a metal "wave type" diaphragm at the actuating lever.

The KLIXON KX4 Sine Switch has maximum clearances between current carrying parts. It can be ganged easily for multiple pole operation and is adaptable to many types of actuation.

Other features of the KX4 include:

- **HIGH CURRENT CAPACITY** . . . unique design of Sine Blade eliminates knife edges . . . provides double current path through blade . . . gives efficient heat dissipation and long electrical life.
- **HIGH SHOCK AND VIBRATION RESISTANCE** . . . precise operations unaffected by shock as high as 200 g's . . . vibration of 40 g's, 0-500 cps.
- **WIDE AMBIENT TEMPERATURE RANGE** . . . continuous operation at temperatures as high as 200°F . . . precise operation unaffected under rapid cycling from −65°F to +200°F within five minutes.
- **STANDARD SIZE** . . . meets mounting requirements of Military Standard AN3234.

Technical Data Sheets on the KX4 and other KLIXON Sine Switches now in production are available. Write for Bulletins PRSW-2, 3, 4 and 5.

Basic KX4 Sine Switch | KX4 with leaf actuator | KX4 with roller-plunger actuator | KX4 with roller-leaf actuator | KX4 with roller-leaf actuator

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
FOREST STREET, ATTLEBORO, MASS., U. S. A.

KLIXON®

Circle 447 on page 19

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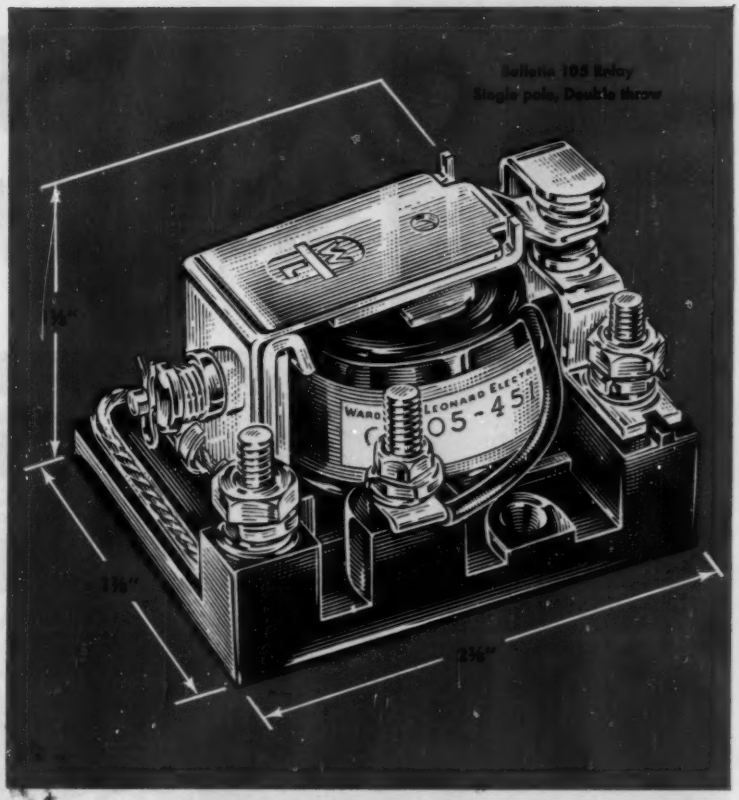
More relay for your money—that's the big thing you get when you specify Ward Leonard's Bulletin 105 for light power switching jobs.

No delicate, misapplied telephone- or instrument-type relay, the 105. From rigid phenolic base to ample silver-to-silver, self-cleaning contacts, the 105 is built to deal with *power* . . . just like the larger Ward Leonard relays and contactors. And yet it's extremely compact and low in cost.

You'll find the Bulletin 105 relay—in SPST, SPDT, DPST, and DPDT types—ideal for controlling power to electric heaters, signals, pumps, radio and TV transmitters and public address systems.

Check your catalog file today for Bulletin 105. If it's missing write to: Ward Leonard Electric Co., 58 South Street, Mount Vernon, N.Y. (In Canada: Ward Leonard of Canada Ltd., Toronto.) 7.1



ENGINEERING DATA

SINGLE POLE BULLETIN 105 RELAY

Contact Ratings

Volts	D.C. Amps.* N.O.	D.C. Amps.* N.C.	A.C. Amps.* N.O.	A.C. Amps.* N.C.
0-24	20	15	20	15
25-125	½	½	20	15
126-250	—	—	15	10

*Ratings are non-inductive.

COIL VOLTS: 6, 8, 10, 12, 24, 32, 48, 115, 230
AVG. COIL WATTS: 2 D.C., 3.75 A.C.
PICK-UP: 85% or less of rated voltage
WEIGHT: 5 ounces
TERMINALS: Stud type

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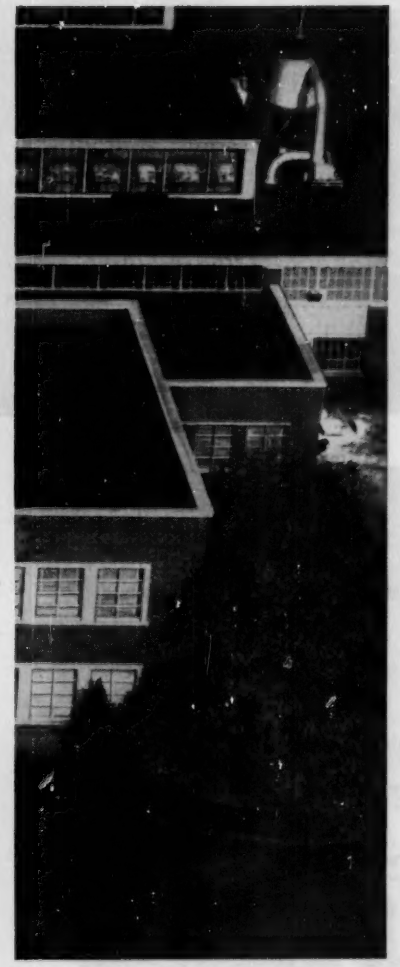
Circle 448 on page 19

Headquarters of the Metallurgical Products Department of General Electric Company, 11126 E. 8 Mile Blvd., Detroit 32, Michigan. Carbides, vacuum-melted alloys, and hevimet are made here. G-E permanent magnets and speciaity resistors are manufactured in the Edmore, Mich., plant.

CAN LOOK FORWARD TO FROM GENERAL ELECTRIC'S PRODUCTS DEPARTMENT



The new G-E Metallurgical Products Department is the successor to the Carboloy Department. Here's what this change will mean to you.

Since 1928, the General Electric trademark "Carboloy" has been identified with a brand of cemented carbide. First used solely as a cutting tool material because of their strength and toughness, carbides have more recently become one of the designer's most effective wear-proofing materials.

Carboloy® cemented carbides are manufactured by the new Metallurgical Products Department—successor to the Carboloy Department, which G-E organized to produce this metal for industry. But today carbides are just one of a broad range of products and materials this Department manufactures—many of which do not carry the famous Carboloy trademark.

These include G-E Alnico permanent magnets, thermistors, and Thyrite® varistors which have helped solve many basic design problems in the electrical and electronics industries. And G-E vacuum-melted alloys, and hevimet, which are now making important contributions to advanced aircraft, automotive, and atomic energy programs.

Thus, the new departmental name symbolizes the broadened scope of this Department's activities . . . a scope which will have far-reaching effects for design engineers in every phase of industry.

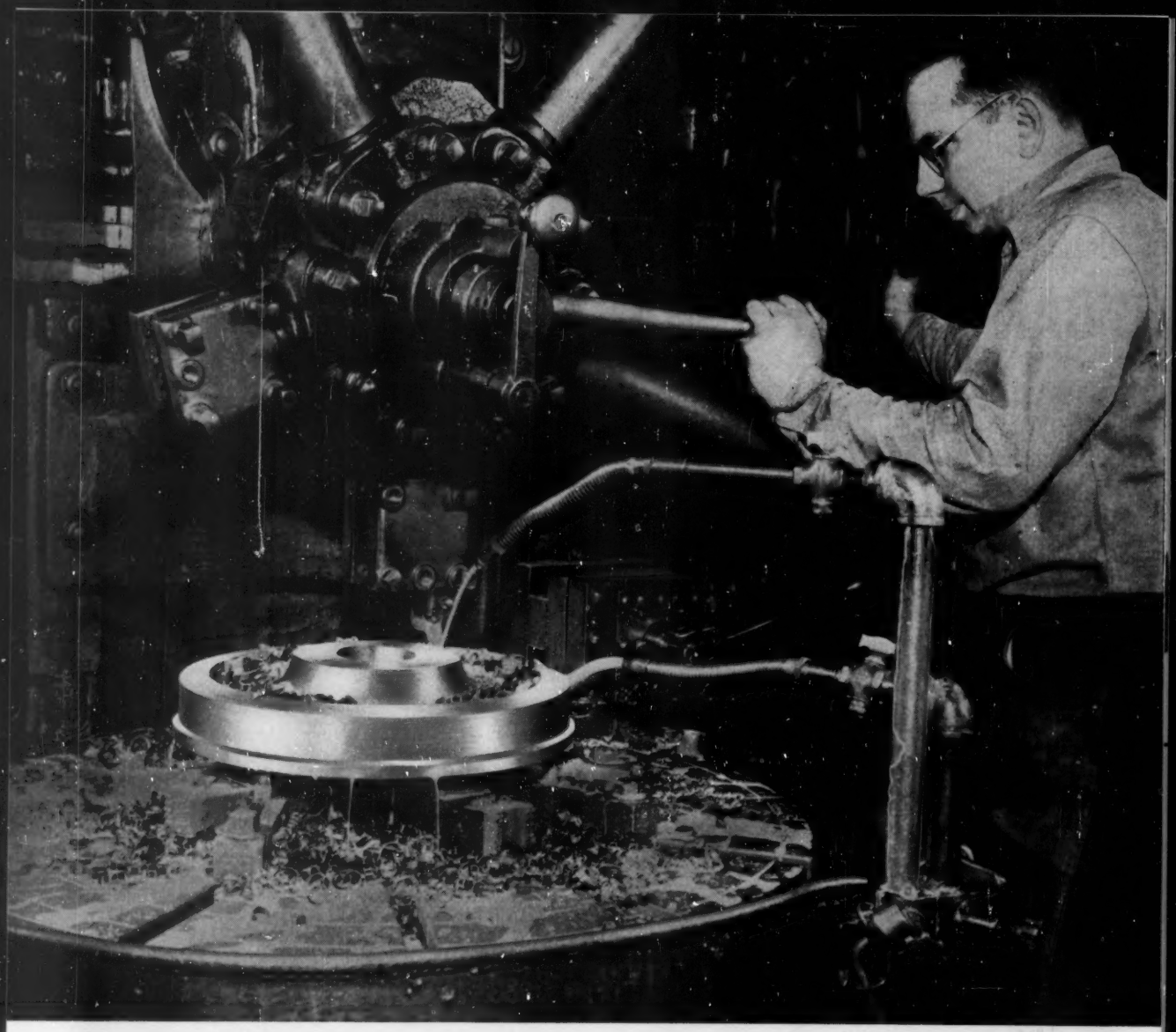
For General Electric – through its Metallurgical Products Department and the G-E Research Laboratory – is carrying on fundamental investigations which are extending the frontiers of metallurgy.

For example, the process which created G-E man-made diamonds may yield new structural and design materials which do not even exist in nature. And General Electric's work in powder metallurgy, metallic oxides, and semiconductors – which produced many of the products mentioned above – has a fascinating future all its own.

New products, and new methods of utilizing these products, are on their way. And when they are developed, they, too, will come to you from the new G-E Metallurgical Products Department.

Progress Is Our Most Important Product

GENERAL ELECTRIC



Another Good Gear on the Way

Here's a piece of work that is destined to become a transmission gear. The machinist has found it easy going because of the highly dependable blank he's using. Right from the start, he has had smooth sailing.

The blank was made by Bethlehem's forging-and-rolling process, a method of manufacture that is unique. By combining both forging and rolling in a single operation, this process imparts uniform density and smooth, regular grain flow. As a result, the metal cuts away cleanly and fast, and there is no hidden trouble to plague the machinist.

This is important. But even more important is *strength*. In Bethlehem blanks, there's strength in abundance—the strength and soundness essential for gears, crane wheels, sheaves, flywheels, and other circular products.

These sturdy steel blanks can be furnished in sizes to 46 in. OD, so there's a wide range of choice. There's also available an excellent variety of sections.

For full details, we suggest you call our nearest sales office—or write for Booklet 216, which contains more than 80 photographs and a wealth of helpful information.

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On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 450 on page 19

LONGER SOLENOID LIFE...

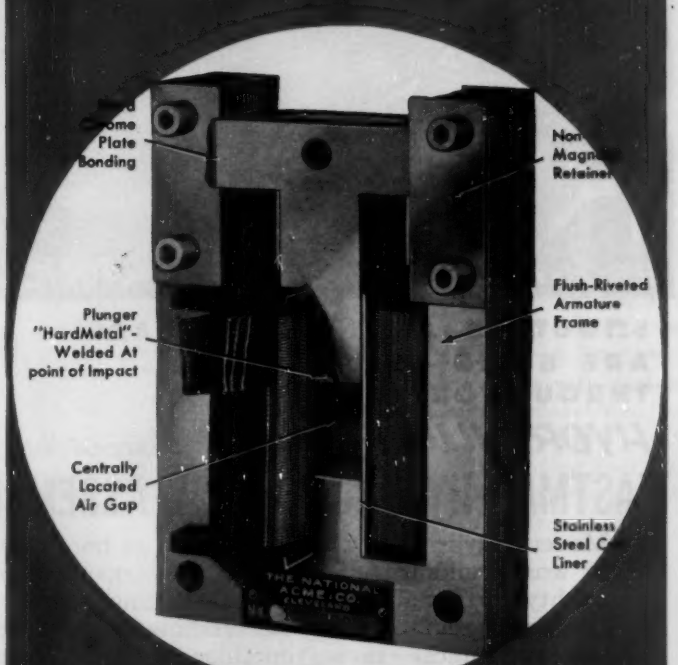
with NAMCO'S exclusive "HARDMETAL"-welded plunger bonding

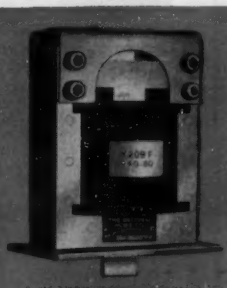
Standard or Custom Models To Fit Your Design

"HardMetal"-welded plunger bonding prevents mushrooming at the vital point of impact—withstands incessant pounding of the plunger on the frame. Long plunger life, and thus long solenoid life, is further insured by hard chrome plating upper guide edges of plunger laminations to reduce friction and wear.

Namco standard solenoids are available in six series of pull and push types; custom-engineered solenoids in every size and type can be made to meet your specifications.

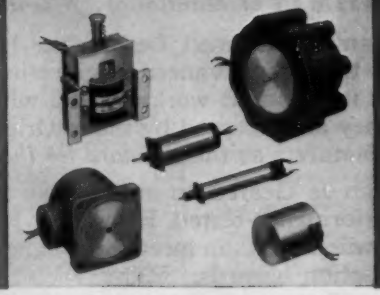
Standard "HardMetal"-Welded Solenoids are furnished push or pull type in sizes with ratings from 2-1/2 to 21 pounds at 1/2" stroke and from 2 to 25 pounds at 1" stroke.





← Saddle stop applied to Series K200 standard Namco push type solenoid.

To meet specific job requirements, solenoids of special shapes and sizes are designed and built through cooperation of our engineers with yours. →



Ask us to send a National Acme Representative to discuss your problems, or if you want more information first—send for BULLETIN EM-52.

ELECTRICAL MANUFACTURING DIVISION

National Acme

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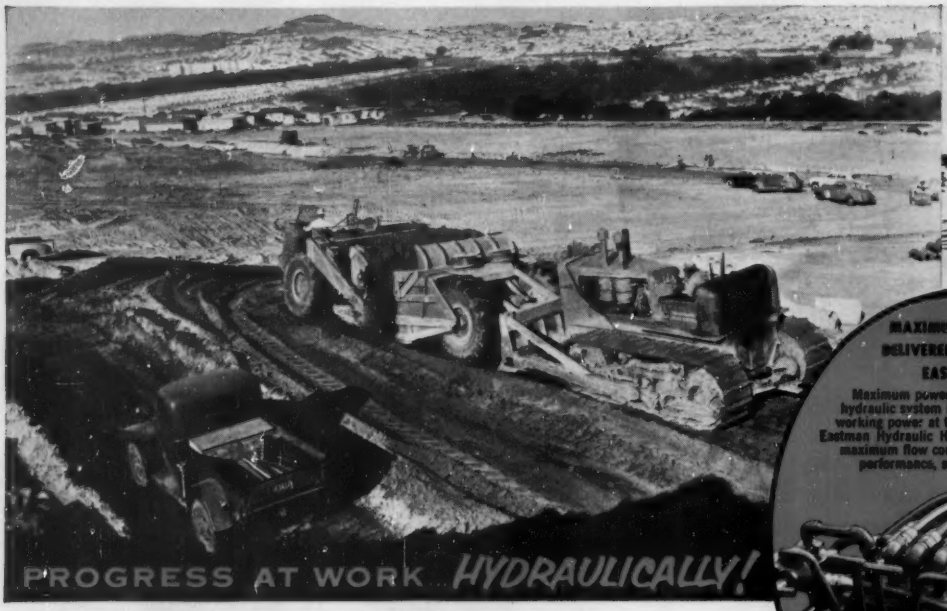
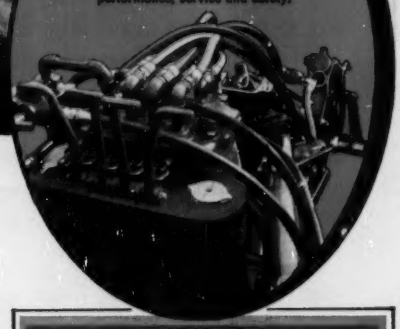
Circle 451 on page 19



America's Future Lifeline of Travel

MAXIMUM POWER DELIVERED THROUGH EASTMAN

Maximum power delivery for every hydraulic system is the key to efficient working power at the point of operation. Eastman Hydraulic Hose Assemblies provide maximum flow consistent with efficient performance, service and safety.



SMOOTHER AND SAFER ROADS ARE BEING BUILT FASTER... THROUGHOUT AMERICA *with*

HYDRAULIC POWER delivered thru

EASTMAN HYDRAULIC HOSE ASSEMBLIES

Modern Hydraulics will put millions of horsepower to work building America's roads . . . maneuvering mighty earth-moving machines with finger-tip ease. Grading, loading, leveling and finishing will be easier, more economical—saving time, money and manpower.

Many Pioneer Manufacturers of modern road building equipment have, from the beginning of hydraulics—equipped their machines with Hydraulic Hose Assemblies made by the very first pioneer manufacturer in this field—EASTMAN of Manitowoc, Wisconsin.

Eastman's Continued Leadership has been maintained through advanced engineering and design—plus materials and workmanship which are so high that they are accepted by many Original Equipment Manufacturers as the *standard for the industry!*

Eastman Is Geared to supply the critical demand for performance-tested Hydraulic Hose Assemblies which will more than meet the roughest road building construction hazards. Many 'round the clock operations will now run into year-'round schedules, and Eastman's new production facilities stand ready to provide *dependable shipments, service and satisfaction.*

FOR INCREASED EFFICIENCY IN HYDRAULIC POWER
Specify EASTMAN
HYDRAULIC HOSE ASSEMBLIES

EASTMAN'S NEW "HI-FLO" COUPLING DELIVERS A MAXIMUM OF POWER

EXCLUSIVE GRIP ADVANTAGES WITH INTER-LOCK ® CLAMP COUPLING

CUT COSTLY "DOWN-TIME" WITH EASTMAN RE-USABLE COUPLINGS

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WRITE **for bulletin to suit your needs or send specifications**

Circle 452 on page 19

Circle 453 on page 19→

NOTHING *can equal Stainless Steel*

in its unique combination of properties

No other design material can match Stainless Steel in its unique combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. If you're looking for a reliable source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

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SHEETS · STRIP · PLATES · BARS · BILLETS
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UNITED STATES STEEL

For Formability...

Jet engine and pressure vessel makers are using roll-formed rings in large numbers these days. Alloy Manufacturing Company in Pittsburgh is a major supplier of Stainless Steel fabricated parts, and they process this steel on ordinary "carbon steel rated" equipment without difficulty.

For Cleanliness...

Bates Manufacturing Company, Lewiston, Maine, is a famous name in cotton goods. They used to have trouble with dyeing equipment; the iron vats held the old colors and "killed" new colors. With Stainless Steel dye kettles, old colors actually *rinse* out, without costly scrubbing.

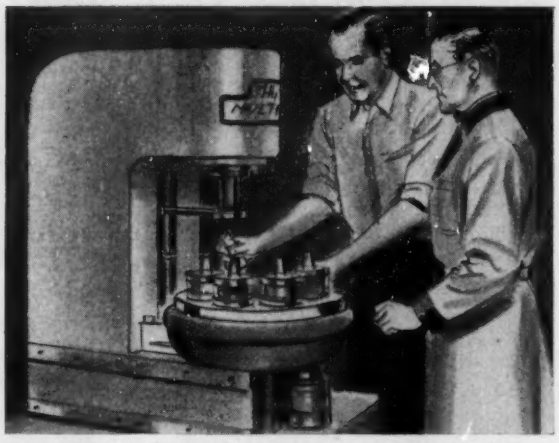
For Style...

G & G Woodcraft, Dinette Division, in Detroit, is selling a handsome new dinette table, designed by Gelitis, with a polished Stainless Steel top. The top is backed with plywood, and there is no metallic sound when it is struck. Stainless is a perfect material for contemporary design, and it's so *practical.*

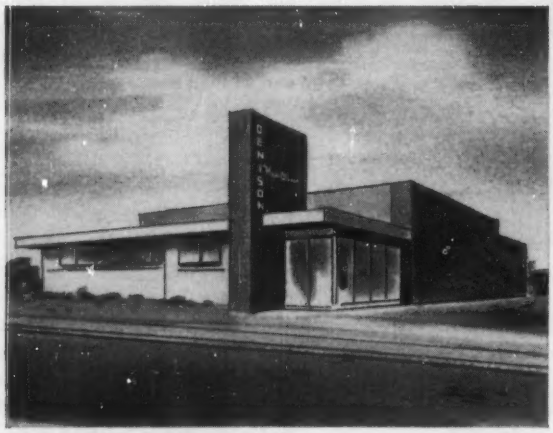
Complete hydraulic service... from one dependable source...

DENISON

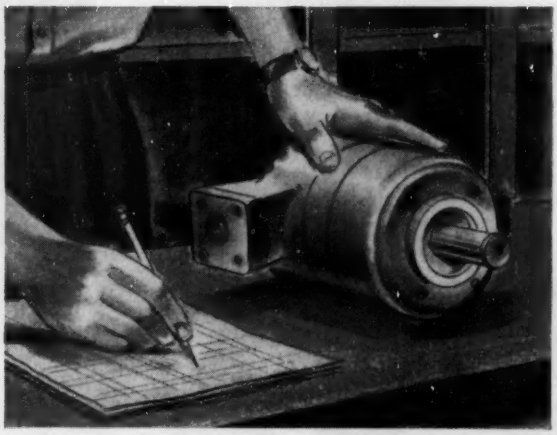
FREE APPLICATION ENGINEERING by experienced hydraulics specialists to improve your circuits.



JOB DEMONSTRATIONS to *prove* how your operations can be made more efficient with the new hydraulic developments.



REGIONAL FACTORY SERVICE includes *complete maintenance facilities* for building, testing, repairing equipment.



OVER-THE-COUNTER SALES from local stock to give you *immediate delivery* of hydraulic pumps, motors and controls.

Behind the name Denison... With its regional warehouses and branch offices, Denison's factory service is now as near as your telephone. Specialists in hydraulics are immediately available to help you build a better product, build it for lower cost.

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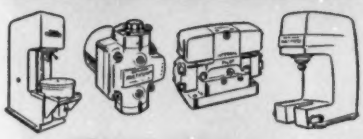
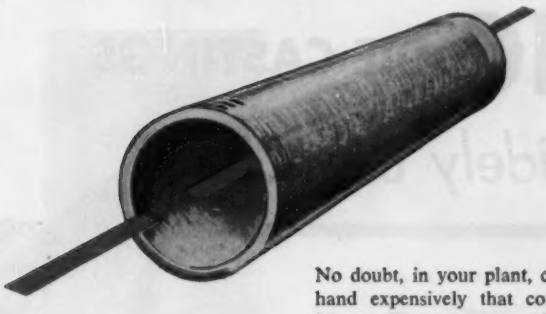
DENISON HydrOILics



HYDRAULIC PRESSES • PUMPS MOTORS • CONTROLS

if it can be pushed through a pipe . . .



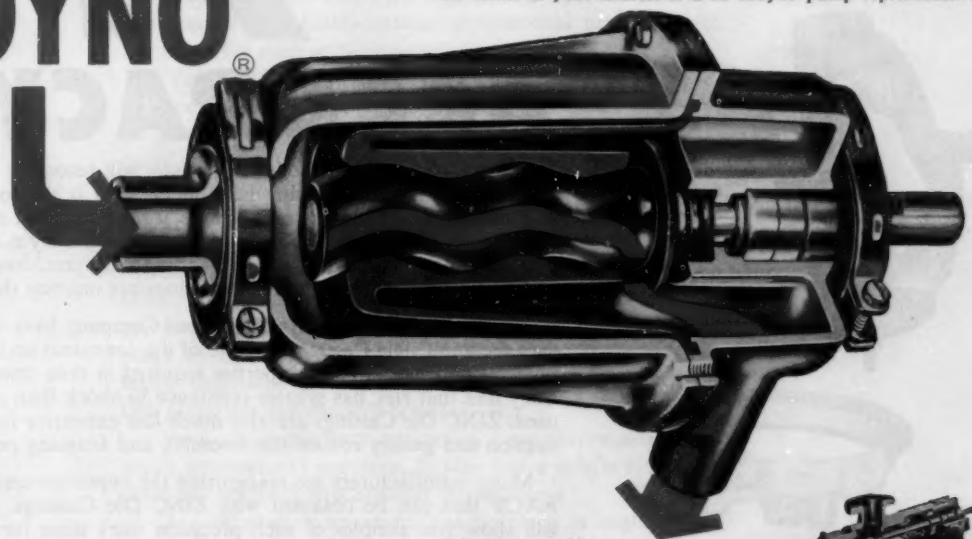
you can pump it with a

MOYNO®

No doubt, in your plant, certain materials are being moved by hand expensively that could be pumped economically by a Moyno. They pump anything that can be forced through a pipe . . . from very thin liquids to heavy, non-pourable abrasive substances . . . even materials containing suspended particles! As the illustration shows, progressing cavities, formed by the helical screw-like rotor turning inside the double-helical stator, move smoothly along, carrying the material with them . . . the cavities don't squeeze the substance . . . can't stick or gum up. Moyno pumps will not cause churning, foaming . . . won't aerate or vapor-lock!

Moynos are adaptable for a wide range of substances simply by modifying the materials the pumping elements are made of. They are available to pull up to 29" of vacuum while discharging under pressure. If you have a pumping problem, chances are a Moyno will solve it!

Write today, for Bulletin 50 MD or look in the yellow pages for name of your nearest R & M Moyno pump representative.



Industrial type Moyno . . . available to 500 gpm, pressures to 1000 psi.

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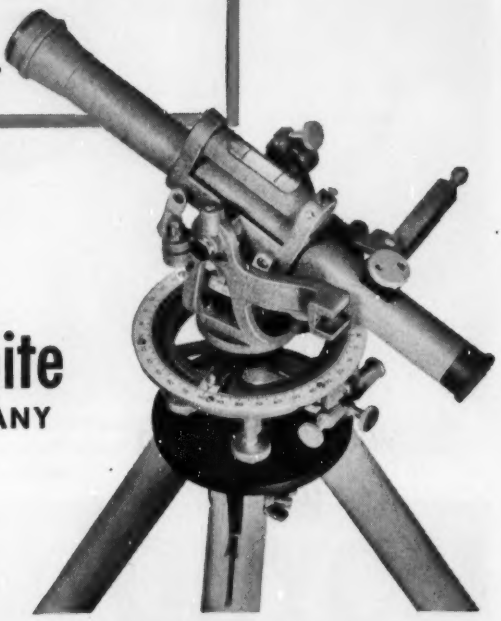
There's a Good Reason why

ZINC DIE CASTINGS

are so widely used . . .



at David White INSTRUMENT COMPANY

IT'S

ACCURACY

You may never need a theodolite, but you will recognize the importance of accuracy in this surveying instrument. This is the tool that enables engineers to build bridges and tunnels from both ends and make them meet exactly in the middle. It also helps surveyors lay out highways and property lines. Any instrument demanding such precision must be made of very accurate parts. ZINC Die Castings are meeting that need.

Engineers at David White Instrument Company have a strong preference for ZINC Die Castings because of the consistent accuracy and other physical and mechanical properties required in their transits and levels. They find that zinc has greater resistance to shock than metals formerly used. ZINC Die Castings are also much less expensive for quantity production and greatly reduce the assembly and finishing problems.

Many manufacturers are recognizing the important quality of ACCURACY that can be obtained with ZINC Die Castings. Any die caster will show you samples of such precision work done for his customers. It may be that these examples will suggest improved qualities and cost savings for your products.

THE NEW JERSEY ZINC COMPANY 160 Front Street, New York 38, N. Y.

The research was done and the Zamak die casting alloys were developed with

HORSE HEAD SPECIAL (99.99 + % Uniform Quality)

ZINC FOR DIE CASTING ALLOYS

MACHINE DESIGN
January 24, 1957

False Modesty Hurts

EVER hear of a carpenter disclaiming any skill in wielding a hammer or saw? Or a trumpet player who bragged about his sour notes? No, where skill is the essence of a man's calling, professional pride is much too fierce for such self-depreciation.

Yet, curiously, there are persons professing to be engineers who act otherwise. Some not only admit but seem to glory in their lack of skill in handling the essential tools of their profession. They even cheerfully confess ignorance of basic mathematical techniques. Or they boast that published articles and papers are "too highbrow" for them.

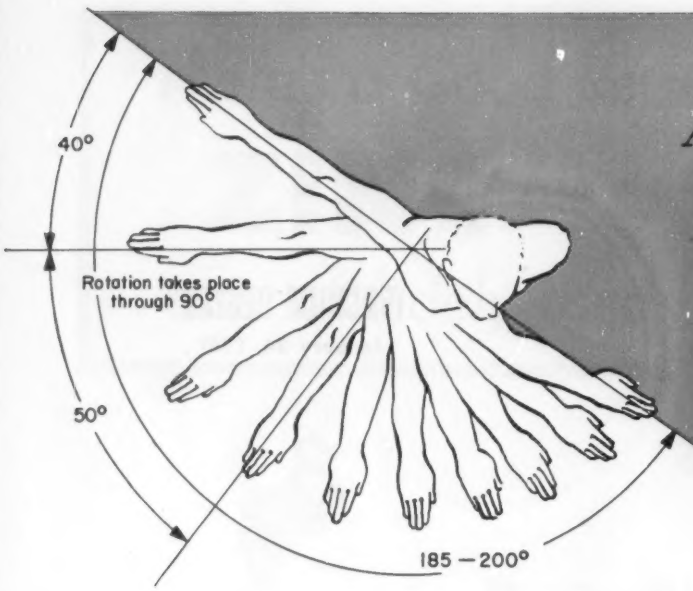
Some engineers disdain other hallmarks of professionalism. For instance, a doctor's or lawyer's kit includes the assured professional manner—the air of complete command of the situation, of knowing his way around. How many engineers cultivate this air of competence? And how many act like country boys?

Such false modesty creates a poor impression of a man's professional standing. It also has a subtle retarding effect on his own professional development.

A hick, real or apparent, has no place in engineering. He only hurts the standing of the whole profession.

Colin Carmichael

EDITOR



A Survey of HUMAN ENG

By Richard S. Barrett
Vice President
Personnel Research and Development Corp.
Cleveland

ENGINEERS engaged in the design of machinery and equipment are becoming increasingly aware of the impact of human engineering on their design problems. This is even more true of those who design equipment to be sold over the counter to a consumer. It is no longer enough to have a piece of equipment that has sound mechanical design, utilizes modern materials and is smartly styled. To keep abreast of competition, the designer must include provision for making it easy to use, safe and comfortable. If this is not done, he will find that other designs, which are not intrinsically better from the engineering point of view, will achieve greater acceptance among purchasers.

Engineering training directs designers to consider the operations that a machine is to perform. The lathe must cut so many pieces within specified tolerances. The oscilloscope must present certain items of information about the machine being tested. The airplane must be capable of certain characteristics of climb, turning and stall. However, each of these pieces of equipment must be operated by a human being. If he is considered in the designing process, the machine is more likely to be able to accomplish what it was intended to do.

During the war, the government developed an aid for statisticians called a Matrix Rotator. The device automatically plotted graphs and rotated the axes in order to aid in some statistical computations. The data were visible on a cathode-ray tube and were adjusted by dials manipulated by the statistician. When he had achieved the proper results, a camera swung down, photographed the cathode-ray tube and then swung back out of the way. The two essential operations were (1) observing the tube, and (2) manipulating the dials. Unaccountably, these were placed about three feet away from the tube and positioned so that the operator had to twist his neck to see the tube.

When a statistician inquired why these dials were placed in such a position, it was carefully and patiently explained to him that they had been placed where they were in order to make maintenance easy. Besides, moving the dials would mean the addition of a couple more feet of cable. If the designer had paid a little bit less attention to the cost of several feet of cable or the time consumed in the very infrequent maintenance procedures, he could easily have developed a console near the tube which would be much easier to operate. To add injury to insult, the swinging camera was a menace which clipped many an operator behind the ear.

Examples of failure to design for the operator are legion. For instance, pilots dressed in high altitude pressure suits with cumbersome gloves, which restrict the motion of the fingers, are required to turn around in their seats and flip small toggle switches. These switches are easily manipulated by a person sitting on the ground wearing an ordinary uniform, but in high altitude suits, it is almost impossible to hit the right switch without knocking one or two of its neighbors out of line.

Until recently, the operator of a drag line, costing more than a million dollars, sat on the same sort of bucket seat and manipulated the same kind of controls that were fashionable twenty years ago in the cheapest steam shovel. Placing him in an air-conditioned cab with a comfortable seat, improved controls and improved communications increased his production tremendously.

INEERING

For a design engineer, the usefulness of human engineering depends upon two considerations. First, human engineering is a new and rapidly growing field which suffers from a lack of information in some areas. Second, some of the fields of human engineering are readily applied by persons without psychological training, while others are not. A designer who wishes to apply human engineering principles should take advantage of the studies that have been made in areas pertinent to his field. This article reviews the subject and outlines the present state of development of the field.

The operator of a currently manufactured steam roller has to stand up and swing around on a narrow platform to see where he is going when he backs up, even though almost half of the operations of a steam roller are performed in reverse. Finally, there was the piece of equipment designed by a left-handed engineer which was comfortably operated only by left-handed people.

How does a designer go about designing for the operator? There are many ways and no one of them is suitable for all situations. The techniques will vary depending on the complexity of the equipment, the importance of the operator's function and the designer's knowledge of solutions for similar problems.

The first and most obvious thing to do is to find out what the equipment is to be used for, what operations take place, in what sequence and how often. The time necessary to collect such information will depend on many things. In some cases it may be worthwhile to build a working model, select a sample of people, train them in the operation and observe what they do. It may be possible to observe people working with similar equipment at least to learn what mistakes should be avoided. At the very minimum, the engineer should put himself in the operator's shoes and imagine what happens in a cycle of operation to get a feeling for what is being done.

It is important when designing for the operator as well as the operation, to place closely together the controls which are related or which the operator tends to think of as a group. For instance, almost every airplane contains a group of basic flight instruments. The six instruments—the air speed indicator, the compass ,the gyro horizon, the altimeter, the turn and bank and the rate of climb indicator—are found on even the simplest cockpit panels. They are ordinarily arranged in two rows of three each and placed in a central location where they are easily seen. Because these instruments are related and pilots are used to seeing them in this same relationship to each other, it would be risky indeed to design an aircraft cockpit with these instruments in different positions.

The more important and more frequently used instruments and controls should be placed centrally. If you place your elbows on the edge of the table in front of you and scribe arcs with your hands without moving your elbows, you will find that there is an overlapping area in the center which is easily accessible to both hands and an arc to each side which can be controlled by one hand. By casually reaching from a seated position with the arm straight, the limit of comfortable reach can be estimated. Finally, by leaning forward and twisting the trunk, the ultimate limit of reach can be established by a person who does not get up from the chair. The actual dimensions of these arcs for the general population are available.

The implication of these areas of convenient and difficult reach should be, but is not always, obvious. For instance, in complex control panels there are frequently knobs which must be turned to make a setting, switches turned on and off, dials that must be read and indicator lights which tell of some condition existing within the equipment. If the designer thinks carefully about the functions of the operators, he will put the knobs and switches down low and on a shelf out in front of the panel where they can be most easily reached. If there is a dial associated with one of the controls, it should be placed near it so that when the

switch is flipped or the knob turned, the effect can be readily discerned on the nearby dial. Out of reach but still within easy view should be placed the dials which must be read even though they are not associated with any controls. Finally, at the most distant position, are located indicator lights which flash on and off with changing conditions.

Some principles which should be checked when designing for the operator are:

Do not overload parts of the body: The familiar QWERT YUIOP is a classic example on how not to design a typewriter keyboard. The left hand and the weaker fingers do most of the work. It is said that this awkward design was developed because the early typewriters were so mechanically poor that a skilled typist could type faster than the machine could. The machine was deliberately designed to slow down the typist. This is a design principle to be avoided.

Do not present too much information: If a dial needs to be read only in integers, there is no point in dividing it up into hundreds. These divisions only tend to confuse, as ample experimental evidence indicates. Neater, cleaner, less cluttered dials are read more accurately than those which contain several hands or excessively fine calibrations, markings or numerals.

Current Development

To assist the engineer in recognizing which areas he can profit most by applying human engineering principles, the following outline may be helpful. Each area is rated in terms of two considerations. They are:

State of the Art: Some areas pertinent to human engineering have received a great deal of attention from experimental psychologists. This has resulted in a large body of data and theory which are generally accepted among the experts in the field. Other areas, because of their complexity or a lack of concerted effort, have been only partially developed.

Usefulness to Design Engineer: Two considerations determine whether the available knowledge is useful to the design engineer. (1) In some cases, the available information simply does not pertain to design problems. (2) In other cases, the data and theory are too specialized to be useful to engineers. Only a psychologist familiar with design problems can safely apply known principles in these areas to problems.

Effectors

Effectors consist of the nerves, muscles, limbs, etc., which carry out the orders of the brain to do useful work. Under this class we have included measurements of operators since the physical dimensions influence the performance of work more than other functions.

Physical Configurations

State of the Art—Excellent
Usefulness to design engineer—Excellent

A great deal of attention has been paid to the relatively simple anthropometric study of the size and shape of human beings. Countless measurements have been taken and measures of central tendency and variability computed. It is possible to turn to several sources to learn physical dimensions which may be pertinent to design. These dimensions give figures indicating the average dimensions as well as the limits of say, the middle 50 or 90 per cent of the population. With this information it is possible to incorporate dimensions in the design which will make the equipment fit a given proportion of the operators.

Space Required for Activity

State of the Art—Excellent
Usefulness to design engineer—Excellent

Closely allied to the direct measurements of the body are the measurements of the desirable space around a person. Handbooks give information concerning the size of chairs, amount of knee clearance required under a table, dimensions of passageways, etc.

Strength and Accuracy of Movement

State of the Art—Good
Usefulness to design engineer—Good

Measurements are also available of the strength and accuracy with which a person can perform a task. Not only are figures given for the most usual or comfortable, but also indications of the amount of detriment of performance to be expected when a person must operate in an awkward position, as when he turns a knob behind him. Included in this area is information concerning motion study, most of which is familiar to designers.

Use color codes: If lights are to indicate several kinds of conditions, classify the conditions so they are most meaningful to the operator. A light that merely indicates a piece of equipment is on and operating could be white. An amber light could be used to indicate a nonemergency situation which should be corrected at the operator's leisure. A red light or one with a flasher can be used when immediate action must be taken. An example of this is the red line or indicator usually found on temperature and pressure gages.

Take advantage of population stereotypes: We read from left to right and from the top of the page down, so plan check and control procedures with this sequence in mind. Similarly, pushing a switch forward, up, or to the right generally used to turn the power on, while putting the switch down, back, or to the left is used for turning it off.

Place labels where they can be read: It is not enough to label a piece of equipment giving all the information that was required. The designer must also consider the possibility that the label will be obscured when a switch is on or that it will not be visible for lack of proper illumination. If the label is important enough to be included on a

The Senses

Senses are generally divided into two major classifications. The distance receptors are those by which the person learns about the outside world and include sight, hearing, taste, etc. In addition there is a complex system of internal receptors called proprioceptors which tells a person such things as the position of

Vision

State of the Art—Excellent
Usefulness to design engineer—Good

Vision is the means by which most information is gathered from the outside world and is naturally the area in which the most work has been done. Theoretical treatments of depth perception, color-vision, dark adaptation, etc. are probably of little value to the engineer who is designing a piece of equipment. Of greater interest are studies of vision as a source of information. A great deal of information is available on dials, indicator lights, scales and other symbolic ways of presenting information.*

*W. R. Garner and J. W. Gebhard—"Machine Dials and Scales," MACHINE DESIGN, Vol. 21, No. 8, August, 1949, Page 98.

Hearing

State of the Art—Excellent
Usefulness to design engineer—Good

Hearing is the second most useful source of outside information. Like vision, the physiologists are not yet quite sure of the mechanisms by which people hear, despite a large amount of work accomplished to date. However, the experimental psychologists have studied hearing with special reference to communicating information. They have been particularly concerned with the problem of noise and the difficulty of reading through noisy signals. Much of the work is quite technical but some of it is useful to the design engineer. One important consideration is the growing problem of industrial deafness, a problem which no designer of noisy equipment can overlook.

Other Receptors

State of the Art—Good
Usefulness to design engineer—Limited

The other distance receptors are of only minor interest to the engineers. Smell, taste and temperature generally do not need to be considered in the design of equipment.

Proprioception

State of the Art—Fair
Usefulness to design engineer—Limited

The mechanisms which tell us the positions of the various parts of our bodies and also our position in space are not fully understood and are quite difficult to apply to practical situations. Research is being conducted through the Armed Forces with particular emphasis on the problem of orientation in space during flight. Interest in interplanetary travel has fostered considerable research in the problems of living outside the gravitational fields. By the time the average design engineer is concerned with these problems, much more will be known than is available currently.

External Environment

State of the Art—Good
Usefulness to design engineer—Good

The influence of external environment, that is, what is going on outside the human being, has been carefully studied. Heat, humidity, vibrations, noise, dust, etc., have been studied and can be easily and carefully applied by the design engineer.

piece of equipment, it should be placed where it can be read while the equipment is being used and the operator does not have to peer around his hand or some other obstruction in order to read it.

Design for operating flexibility: People vary. Each person has his own way of doing things and may find that one sequence of operations or location of equipment is awkward where another configuration may be better suited to his own personality. Similarly, people get bored or tired and like a change of pace. Equipment should be designed so that they can sit or stand as they prefer and operate a pedal with the left foot or right foot if there is no real reason for having it operated by one foot specifically.

These are only a few principles which will help in designing for the operator. There are many other specific principles. The ones given here are merely illustrations. There are principles which have not yet been worked out but will be an integral part of design in the next five or ten years. In the meantime, the designer can accomplish a great deal simply by using his common sense and trying to see the equipment through the operator's eyes.

Internal Environment

State of the Art—Good
Usefulness to design engineer—Limited

Of little importance to the designer is information about the internal environment, such as the effect of loss of sleep, drugs, alcohol, tobacco, etc. Furthermore, the information is rather technical and best interpreted by someone trained in physiology.

Higher Processes

State of the Art—Fair
Usefulness to design engineer—Limited

Higher psychological processes, as concerned with human engineering, mean such things as perception; that is, how the sensation received through the eyes and ears is organized by the observer, and translated into terms which are meaningful to him due to his unique make-up and experience. It also refers to the problems of motivation; how people are urged to work effectively. Learning processes, the ability to remember and call upon past experience for use in current situations, is another area which has been studied but for which no accepted theoretical framework has been developed. Problems of thinking and decision-making are receiving increasing amounts of attention, but have not yet been developed to a point where it is possible to say that firm conclusions have been drawn.

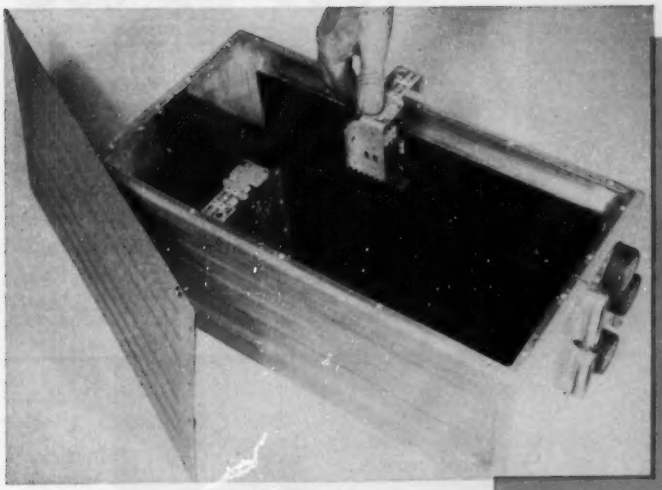
Because of the complexity of these areas and the sketchy nature of the information available, the principles involved are useful only to persons who are professionally trained in psychology. It takes considerable time to learn what has already been discovered in these areas and it takes continual effort to keep up with the latest developments. Rapid strides in these areas can be expected within the next generation; strides which will have useful implications for designers.

Literature of Human Engineering

One of the best all-around sources on human engineering for the design engineer is a recent book by Wesley E. Woodson, entitled *Human Engineering Guide for Equipment Designers*. It was published in 1956 by the University of California Press at Berkeley and is $3.50 per copy. The book is an excellent job of condensing the tremendous amount of data available in the field. Data is presented interestingly in the book which is filled with illustrations, charts and tables which are easily interpreted. Some background is given in physiology, particularly in vision, but most of the material is directly applicable to design problems.

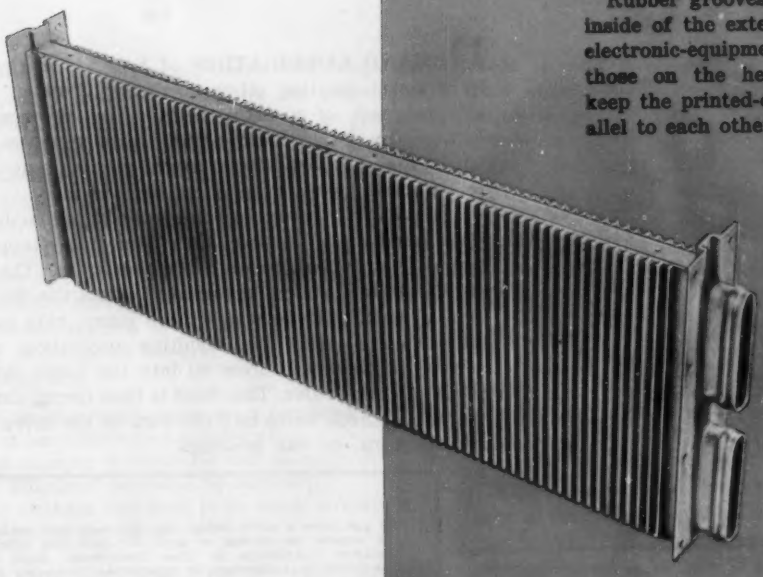
The basic source of information which goes deeper into human engineering data is the *Handbook of Human Engineering Data*, available through the Tufts College Library at $9.00 per copy. It is a compendium of research results in the field of human engineering, collected under the auspices of the Navy. It gives data on the measurements of the body, vision, audition, skin sensitivity, proprioception, motor responses, and physiological conditions and determinants of efficiency, intelligence and learning. Some of the results are of an immediate and practical value while others give the basic underlying physiological or psychological processes. To get information from this handbook requires considerably more digging than from *Human Engineering Guide for Equipment Designers*, but due to its thoroughness, it contains information which is not available in any other source.

scanning the field for Ideas

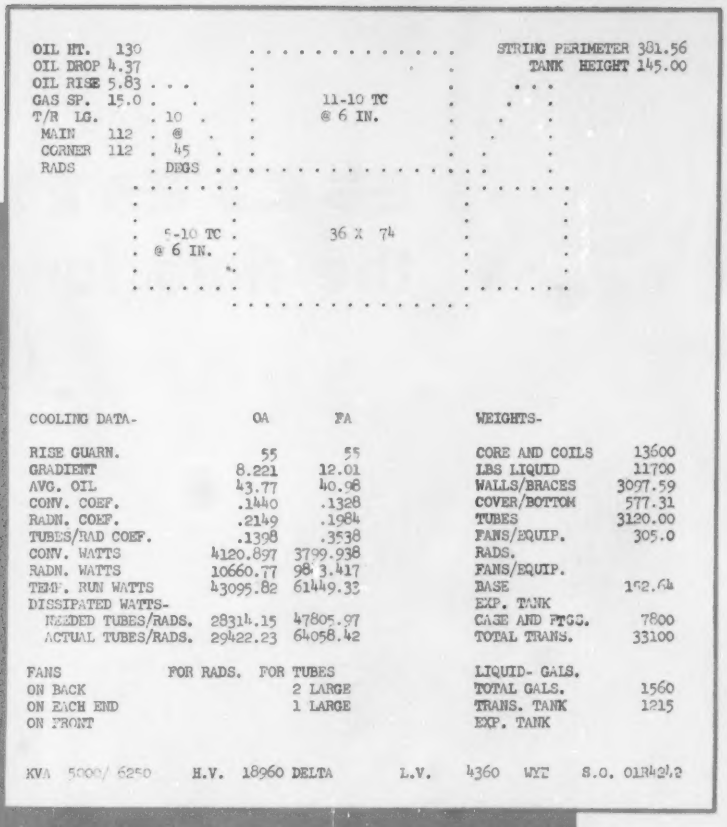


GROOVED HEAT - EXCHANGER SURFACES offer an effective method of increasing heat-dissipation capacity of electronic equipment and provide slots for holding prefabricated circuit assemblies. A cold-plate type heat exchanger developed by United Aircraft Products Inc. forms the center partition of electronic-equipment assemblies designed for slide-in type printed-circuit shells. The heat exchanger core, made of aluminum, is dip-brazed, and then vertical grooves are machined into the core to meet design requirements. The completed heat exchanger assembly is given a black anodized finish to increase heat absorption effectiveness.

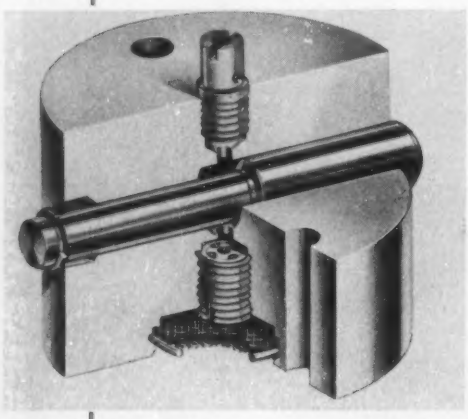
Rubber grooves attached on the inside of the exterior walls of the electronic-equipment case match those on the heat exchanger to keep the printed-circuit shells parallel to each other.



IDEAS



AUTOMATIC PROCESSING OF DESIGN DATA into printed and graphical form with an electronic digital computer reduces design and development time for electrical assemblies. At the Westinghouse Transformer Div., an IBM 705 electronic data processing machine is used in the design of complex power transformers. In minutes after design specifications are fed into the computer, complete electrical design information is printed out, in detail, on a sheet of paper. In addition, much of the mechanical design data, including an outline drawing of the core and coils, are provided. The transformer core-and-coil sketch is produced by the automatic typewriter by means of several properly located periods.



DEMAND LUBRICATION of bearings is provided by a novel rotating oil-pump design. Built-in as an integral part of a drive shaft, a piston pump developed by Bijur Lubricating Corp. operates only when the drive shaft rotates. Pump output is directly proportional to shaft speed.

The complete pump and flow-control assembly consists basically of an inlet check valve, a pump with stepped-piston, and an outlet check valve. The ends of the stepped piston, extending beyond the diameter of the cylindrical housing of the pump, ride against an eccentric race. The resulting oscillating action causes the piston to draw oil into the pump through the inlet check valve. This fluid is then forced through the outlet check valve into the bore of the drive shaft and, in turn, to the bearings.

Do you have a novel design idea for our other readers? You can receive ten dollars or more for each idea accepted for exclusive publication in this department. Send a short description plus drawings or photos to: "Scanning the Field for Ideas," MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Evaluating the need for...

Training an engineering staff to use...

Computers as Design Tools

Computers can be very powerful tools in engineering design work. A vigorous, but cautious, program of training and familiarization can be followed which will lead to the intelligent application of such machines, even in a relatively small engineering organization.

By J. Coleman White
Large Motor and Generator Engineering Dept.
General Electric Co.
Schenectady, N. Y.

INCREASING engineering output and engineering quality without increasing the number of engineering personnel involved is a problem presently facing many engineering departments. One possible method for obtaining the required increased engineering output and quality is to use a computer to perform the bulk of routine engineering calculation. Engineers are thus freed of these tasks and have more time for actual creative and productive effort.

When consideration is given to the possibility of using a computer several questions naturally arise. These are:

1. How can the organization use a computer?
2. Can it be justified economically?
3. What training of personnel will be required?
4. Will additional personnel be required?
5. What changes will have to be made in current engineering procedures?

Each of these questions gives rise to a host of others. These are, however, the major ones, and they must be answered before a decision can be made to obtain a computer for engineering use. This article outlines a procedure which might be followed, particularly by small organizations, to arrive at some of the answers to these questions. Admittedly, some answers depend almost entirely on the characteristics of the engineering organization concerned and the job to be done. Although certain parts of the following discussion apply specifically to digital computers, the same principles apply equally to those of the analog type.

How Can a Computer Be Used?

There may seem to be little point in considering how a computer may be used unless its purchase can be justified. It is impossible, however, to determine whether or not purchase can be justified without first thoroughly studying possible uses. Until the potential use of the computer has been

determined, dollar figures are relatively meaningless.

A computer is not simply an animated slide rule. A true picture of its potential use cannot, therefore, be obtained by looking at published calculating speeds, costs, and the engineering problems now being calculated by hand. Someone in the organization must become reasonably familiar with the details of programming and computer techniques. This requires time and effort. For a proper job to be done, one or more engineers must be assigned this task of computer familiarization and be given sufficient time and facilities to complete the self-education required. Experimentation is an essential part of this education process, and this takes time.

The person or persons undergoing this initial familiarization process should be engineers who are thoroughly acquainted with the work of the organization. In particular, the use of especially hired personnel to tackle this problem, such as young engineers without experience or mathematics majors without technical background, should be discouraged. Engineers selected should not be bound by tradition, however, since the application of the computer will suggest new and better ways of doing the work to be done.

There is one other absolute requirement. In this familiarization program, a computer of some sort must be available for use. In a large corporation, the solution may be a simple one, in that computers may be in use in other engineering departments. Also, some accounting groups may have digital computers in operation with time available for engineering operation. If no machine is available for training and experimentation, use may be made of the familiarization programs offered by most computer manufacturers. In addition, some universities offer training along this line.

The process of familiarization should proceed logically. Simple, perhaps academic, problems should be attempted first. As programming ability improves, the simpler routine engineering calculations familiar to the student can then be programmed. Progress from this point is then apparent and natural. Ideas in programming and computer application begin to be self-generating. A picture of the possible application of a machine in the organization begins to develop.

The particular computer used during this familiarization program is relatively unimportant, as long as its size is not appreciably different from the one that may be used ultimately. Although specific programming details vary from computer to computer, the fundamentals are universal. Because of their great flexibility in programming and application, a stored program computer may be desirable, although other types also have their advantages.

Once this familiarization program has been completed, a decision can be made on whether or not to order a computer. This decision should be based on reduced time required for routine calculation, better engineering methods possible, optimization of design, etc. Many of the advantages will be difficult to evaluate in strictly economic terms, even though the value may be appreciable.

Educating Programmers

When a computer has been ordered, it is necessary to take steps to prepare for its arrival. This involves the development of standard programs to handle the routine calculations of the group. Caution should be exercised at this stage to prevent either of two basic errors. These are: (1) trying to incorporate so many innovations in the programs that they never become completed or do not become acceptable to the engineers who are to use them, and (2) programming the calculations as they are done by slide rule and then succumbing to the natural human resistance to change. Some compromise between these two extremes is necessary. Logically, the development of programs should proceed through three phases in this order:

1. Programming of current calculations as they are now done by slide rule. This should be completed before the arrival of the computer if possible.
2. Improvement of these programs from the standpoint of the most effective use of the machine.
3. Development of new techniques, both from an engineering and a mathematical standpoint, to further improve the effective use of the machine and the quantity and quality of engineering output.

The second and third phases can occur in sequence after the computer has been received and put to work on the programs of the first phase. Time must be spent to gain future time. The programs of the first phase will help to release engineering time for the later phases.

At least one capable programmer must be developed in each identifiable subdivision of the organization. He would then, logically, handle the programming for his particular group. Training of these programmers presents a major problem. How this problem is solved will depend, to a considerable extent, on the methods used in the familiarization program. Those who took part in this program may be sufficiently adept at programming and the elements of numerical analysis to conduct internal courses. This is the most satisfactory method if practicable. If not, use may again be made of standard programming courses offered by the computer manufacturers.

Study of numerical analysis techniques is an essential part of a digital computer training program. Much of this will consist of information studied in college but long since forgotten through lack of use. Since a digital computer is operated numerically, rather than algebraically, education in the more sophisticated methods of numerical analysis will pay dividends. The particular curriculum used will vary with the nature of the engineering organization. A curriculum which worked well with an organization devoted to the design

A Suggested Computer Training Curriculum

This outline represents one curriculum used to train the engineers of a moderate-sized organization in numerical analysis and the use of a digital computer. It certainly does not represent the only curriculum available, nor the best for any specific case. Items in the curriculum might receive different emphasis, depending on the nature of the work of the group, and the type of computer.

The curriculum is laid out to cover seven weeks. A total of five hours each week were devoted to the program: two hours of lecture on numerical analysis, two hours of lecture on computer techniques and one hour of computer laboratory. The numerical analysis and computer sections may be handled separately, although they should be co-ordinated for greatest effectiveness.

Numerical Analysis	Computer Techniques	Problems
First Week: Solution of simultaneous linear algebraic equations by substitution methods (Gauss, Cholesky, etc.) and by iterative methods (Gauss, Seidel, etc.).	First Week: Basic idea of computer operation. Major components of a general computer. Specific components of this computer. Stored program concepts. Description of information flow in machine. Number form and instruction form.	First Week: No Problem.
Second Week: Curve Fitting. Fitting of exact data by selected points and/or slopes. Fitting of approximate data by method of least squares. Taylor series expansion.	Second Week: Basic arithmetic operation codes. Handling of decimal point (scaling). Sample problem involving basic arithmetic operations, such as evaluation of ratio of two polynomials.	Second Week: Problem involving only basic arithmetic operations. Could be derived from the actual engineering work of the organization.
Third Week: Matrix manipulation. Multiplication and addition of matrices. Inversion of matrices. Characteristic roots and vectors.	Third Week: Further explanation of operation codes. Branching and loop operation. Sample problem, such as evaluation of e^x by infinite series to assumed level of accuracy.	Third Week: Problem illustrating loop operation. A simple mathematical problem is best, such as evaluation of sin x by infinite series.
Fourth Week: Nonlinear equations. Roots of a polynomial by Friedman's method. Newton's method, applied to a single equation and to systems of equations.	Fourth Week: Principles of program modification. Explanation of appropriate operation codes. Sample problem, such as evaluation of a general nth order polynomial with coefficients in sequence in storage.	Fourth Week: Problem illustrating address modification. Development of a table of a function of two variables and subsequent interpolation to obtain an intermediate value.
Fifth Week: Finite differences. Determinations of derivatives in terms of finite differences. Interpolation and extrapolation. Numerical integration (quadrature).	Fifth Week: Available subroutines. Entry to and exit from a subroutine. Detailed discussion of operator's console.	Fifth Week: Use of standard subroutines in a problem. Again, the work of the organization can be called upon for problem material.
Sixth Week: Ordinary differential equations. Taylor series starting of integration. Runge-Kutta method. Adams' method.	Sixth Week: Floating point subroutines. Detailed explanation of operation codes (symbolic) and use of floating point arithmetic in a problem.	Sixth Week: Problem involving floating point arithmetic. For example, solution of simultaneous linear equations.
Seventh Week: Partial differential equations. Methods of solution of Laplace's equation, Poisson's equation, the diffusion equation and the wave equation.	Seventh Week: Conclusion of discussion of floating point. General discussion of material covered and review.	Seventh Week: Second problem in floating point, drawn from the work of the organization. Integration of an ordinary differential equation would be a good illustration of the numerical analysis material.

of large rotating electrical equipment accompanies this article.

One important aspect of training is the area of communication. This involves an understanding on the part of the engineer of what is going on inside the machine and the ability to interpret results quickly and practically. This concept develops more or less gradually with experience. It depends, to a considerable extent, on the confidence which the man places in the calculations produced by the machine, and this is acquired only through practice.

Group Training

With the core of programmers hard at work developing working programs, attention can now be directed to the rest of the engineering staff. However, the emphasis should be on operation of the machine and interpretation of results, rather than on actual programming. A detailed study of the techniques of numerical analysis should not be required, even for digital machines, but the elements of programming should be taught. Anyone using the machine should be familiar with the rudiments of programming in order to recognize machine malfunctions, program limitations, invalid results, etc. In addition, the individual engineer will be more capable of visualizing new fields of computer application in his work.

The concept of communication is important here, too. Engineers must work with the machine enough —both programming and running problems—so that they develop confidence in the calculating ability of the machine and learn to interpret its operation readily and with ease. One valuable by-product of this group training program is the detection of engineers who might become proficient programmers, and thereby increase their engineering contributions, with more training and experience.

Further Development

With the initial design problems programmed and running, and with routine calculation now being performed by computer, the experienced programmers are now free to strike out in several directions. As before, some control must be exercised to keep progress within the bounds of reasonable assimilation. There is always something that can be done to improve a program, but sooner or later the programmer must settle on a final or temporarily final program and release it for routine use.

Improvements of standard routine calculation programs can take two forms. The use of more powerful methods of numerical analysis can lead to speedier programs and greater accuracy in the use of digital computers. Improvement will also come about partly through additional education of the programmers, experimentation with methods, and the use of the computer itself as a mathematical development tool. An example of this last approach is the use of the computer to determine more accurate expressions to fit empirical data.

The second method of improvement is more ambitious. It involves the improvement of the calculation methods themselves. This in turn involves engineering development. With a computer available to handle the more laborious arithmetic required, more exact analytical methods can be employed. Fewer assumptions need to be made to render an analysis practical. Design methods should then improve steadily.

As the routine programs begin to become stabilized, the natural tendency is to use the computer more and more as a developmental tool. Ability of a digital machine to perform quickly huge quantities of otherwise tedious calculation makes its application to data processing an obvious step. With a digital computer, more reliable design information can be gleaned from test data by the application of statistical methods that were formerly too time consuming. More difficult analytical problems such as the solution of systems of nonlinear differential equations can be attacked with real hope of solution.

Another very real improvement that can be realized is the automatic optimization of designs. Rather than the cut-and-try method of hand calculation, the computer can be made to converge on an optimum design in terms of cost, weight, performance specifications, etc. This is a relatively simple step beyond the earlier routine calculation program.

Blocks To Progress

At several stages in the familiarization phase and during the early period of computer usage, some more or less natural blocks to progress can occur. These result, primarily, from lack of experience in the application of calculating equipment. One or more of these blocks may have been touched upon in earlier discussion, but additional emphasis is in order.

Use of the machine as an animated slide rule is only natural. However, the more powerful methods available with automatic computation should be used. These methods are, of course, assimilated only gradually. Rate of assimilation depends upon ability to put tradition behind and look to the future.

Accusations that the machine might make lazy engineers and that pride in design might suffer as a consequence may be made. All that can be said here is that experience has indicated that the reverse is true. With more time available for creative effort, and with a machine to do the uninteresting calculating, design efficiency goes up, rather than down.

There may be resistance to using the computer because it might make an undetected error. This cannot be denied. However, so might a human being. In fact, it is estimated that the best slide rule operators will make 1000 times as many errors as the least accurate commercially available digital computer. With comprehensive internal checking being built into many medium-size digital machines today, errors become rare indeed.

Needed computer capacity is often underestimated. The experience of several engineering organizations indicated this to be true. In fact, the available capacity seldom equals the need. New methods of calculation, new problems which can be handled, new applications, and improvements to existing methods generate themselves automatically at a greater rate than planning for computer capacity usually anticipates.

Fear of being unable to properly train young engineers in design philosophy and methods if the design procedure is hidden within a computer program may be expressed. The answer to this is a function of proper communication. If the training programs outlined above are effective, there will be no lack of such communication between man and machine. In fact, the ability to vary parameters easily and quickly will tend to improve the engineer's understanding of the details of the design procedure.

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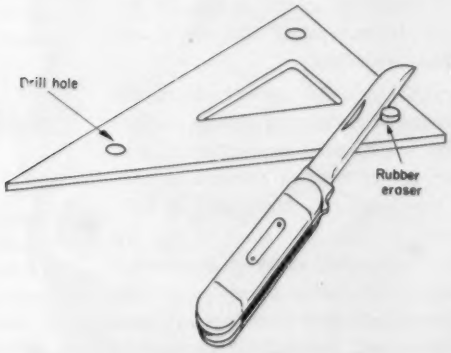
1. M. G. Salvadori and M. L. Baron—*Numerical Methods in* Hopkins Press, Baltimore, Md., 1950.

Tips and Techniques

Skidproofing Triangles and Templates

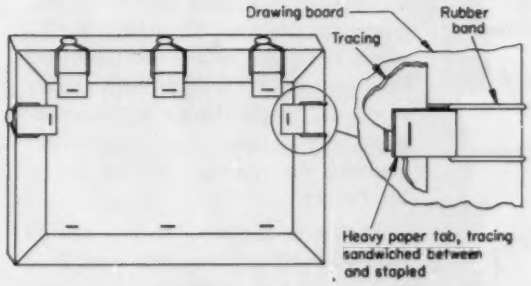
All instruments such as triangles and templates may be easily skidproofed using sections of rubber from ordinary pencil erasers. First drill holes



slightly smaller in diameter than the erasers in the instrument. Then force segments of eraser into these holes. A sharp knife is then used to trim the segments nearly flush with the surface of the instrument.—CHARLES H. WILLEY, *Penacook, N. H.*

Keeping Drawings Flat

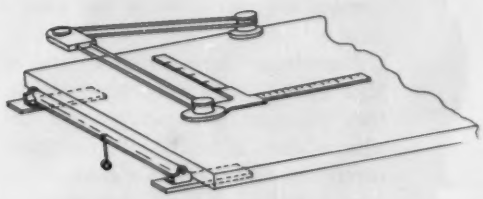
Drafting paper or tracing cloth may be kept flat on the table despite variations in humidity by fastening it securely on one side only and applying slight tension to the other three sides. Tension may be applied by stapling heavy paper tabs or loops to the drawing paper and slipping rubber bands through these loops. Ends of the



rubber bands are then fastened to the edges of the board with thumb tacks.—CARL E. SPAEDER, *DC Motor & Generator Dept., General Electric Co., Erie, Pa.*

Dust Cover

An economical and efficient dust cover for a drawing board can be made from an ordinary spring-roller window shade. Attach a shade of the



proper size with the regular brackets to small blocks screwed to the underside of the board.—W. E. EDGER, *draftsman, Outboard Marine Corp. of Canada Ltd., Peterborough, Can.*

Significance of material

Design for Fatigue

By Joseph Marin

Professor and Head, Dept. of Engineering Mechanics
The Pennsylvania State University, University Park, Pa.

Fatigue failure—in many of its theoretical aspects—remains an engineering enigma. While the mechanism of fatigue failure and its statistical probability are partially understood, no single theory explains exactly why it starts, nor predicts accurately the number of load cycles for failure.

Expose a material to a repeated load—one that fluctuates rapidly—and fatigue failure becomes a definite possibility. History of the event is clear: a small crack starts at a local defect or other point of weakness, and then lengthens and spreads through the material. When the crack has grown sufficiently, the undamaged section ruptures suddenly under the applied load. Such failures occur frequently without evidence of plastic deformation—even in the most ductile materials—and generally when mean stresses are safely below the elastic limit.

Experience with fatigue failures highlights a significant observation: they are most often due to poor design, seldom to faulty material. Best corrective action for this state of affairs is to design on a basis as completely rational as engineering knowledge permits. Understanding of the mechanical properties of materials under simple and combined fluctuating stresses is fundamental to such an approach. With these factors in mind—and with a close eye on the inevitable stress-concentration effects—the designer moves closer to his goal of "fatigue-proof" structural and machine members.

Emphasis in this series tackling the problems of fatigue in design centers on the mechanical properties of materials under fatigue stresses at normal temperatures. Here and in subsequent articles, the state of the art in the following areas is presented:

Design for Static Loads — simple and combined static stresses . . . conventional and generalized theories of strength . . . static-stress concentrations

Design for Fatigue Based on Strength—nature of fatigue . . . completely reversed and varying amplitude stresses . . . theories of failure . . . working stresses . . . fatigue-stress concentrations

Design for Fatigue Based on Factors Other Than Strength—elevated temperatures . . . effects of damping . . . surface conditions

properties in

Loading

Part 1

simple static stresses
combined static stresses

FATIGUE-STRESS conditions frequently result from the superposition of completely reversed stresses and steady-state or static stresses. It follows that strength relationships that are valid for fluctuating stresses in general should be applicable to the two extremes—static stresses on the one hand, and completely reversed fatigue stresses on the other.

Development of strength relations for combined static stresses, which is the subject of this article, is introduced by a consideration of the properties of materials under simple tension and compression stresses.

Simple Static Stresses

For the case of simple tension, conventional procedure is to define material mechanical properties on the basis of a nominal stress-strain diagram, Fig. 1*a*. A more accurate measure of these properties is based on the true stress-strain relation, Fig. 1*b*. In this case, true stress σ and true strain δ are based on the actual area A of the specimen and the actual gage length L rather than on the original values of A_0 and L_0. Familiar relationships between these true parameters are[1]

$$\sigma = \frac{P}{A} \tag{1.1}$$

$$\delta = \int_{L_0}^{L} \frac{dL}{L} = \log_e \frac{L}{L_0} \tag{1.2}$$

Use of True Properties: Recommendations for the use of true properties rather than nominal values are:

1. *True ultimate stress* σ_u be used as a measure of ultimate strength in place of the nominal ultimate stress σ'_u or nominal fracture stress σ'_f.
2. *True strain* δ_u (true strain corresponding to σ'_u) be used as a measure of ductility in place of the usual nominal fracture strain ϵ_f.
3. *True toughness* T (as measured by the area under the true stress-strain diagram to σ_u) be used in place of the conventional modulus of toughness T' (as measured by the area under the nominal stress-strain diagram).

Use of the true values σ_u, δ_u and T, Fig. 1*b*, in

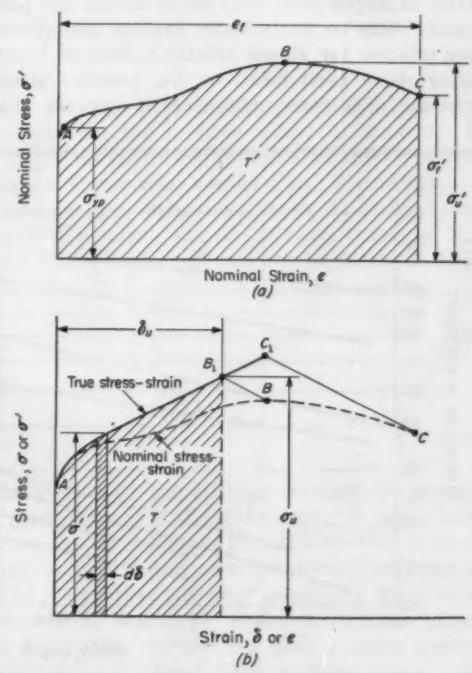


Fig. 1—Nominal and true stress-strain curves.

[1]References are tabulated at end of article.

place of σ'_u, ϵ_f and T', Fig. 1*a*, is recommended not only because the true values are an accurate measure of the stress and strain, but also because for design purposes the part of the stress-strain curves between B_1 and C_1 or B and C, Fig. 1*b*, represents a failure condition for the material.

True stress-strain relations have been obtained in many investigations. These results[2] show that when the true stress and true strain are plotted on a log-log basis the data may be approximated by a straight line, Fig. 2. That is,

$$\log \sigma = n \log \quad + \log k \tag{2}$$

or

$$\sigma = k\delta^n \tag{3}$$

where k is referred to as the *strength coefficient* and n as the *strain hardening exponent*.

Strain δ in Equation 3 is usually taken as plastic strain only. It has been found[3] that the complete true stress-strain diagram may be represented by considering the elastic strain component in writing Equation 3. Total strain is then

$$\delta_T = \delta + \delta_E \tag{4.1}$$

where $\delta = \sigma/E$, the elastic strain.
Then by Equation 3,

$$\sigma = k\left(\delta_T - \frac{\sigma}{E}\right)^n \tag{4.2}$$

or

$$\delta_T = \frac{\sigma}{E} + q\sigma^m \tag{5}$$

where $q = 1/k$ and $m = 1/n$.

Many attempts have been made during the past hundred years to analytically express the stress-strain relation for simple tension.[4] Most of these, however, have been based on the nominal stress and strain. For many materials it appears that Equation 5 is a good approximation for the true stress-strain relation and may be used as a basis for stress analysis and design in the plastic range.

Future fatigue investigations may define failure on the basis of a specified limit of deformation or size of crack rather than on complete fracture of the specimen. It will then become necessary to define static stress failure on the basis of a corresponding true plastic limiting strain. This limiting strain could then be expressed in terms of Equation 5. The formulation of combined stress-strain relations in the plastic range may also be logically based on this equation.

Finding Ultimate Stress: Determination of the ultimate stress point B in Fig. 1*a*, is difficult for many materials because the stress-strain curve is flat in the region of B. For this reason it is difficult to obtain an accurate value of δ_u. A method of more accurately determining δ_u consists in defining the maximum load point B theoretically. In this method, load P is represented by the condition that the slope of the $P - \epsilon$ or $\sigma' - \epsilon$ curve, Fig. 1*b* is zero at the point B. That is, point B is defined by $dP = 0$. The value of the load P in terms of the true stress is

$$P = \sigma A = \left(\sigma A\right)\frac{A_o}{A_o} = \sigma A_o\left(\frac{A}{A_o}\right) \tag{6}$$

In the plastic range it can be assumed that the volume remains constant. Then $A_oL_o = AL$ or $A/A_o = L_o/L$ and Equation 6 becomes

$$P = \sigma A_o\left(\frac{L_0}{L}\right) \tag{7}$$

Placing the value of L/L_o from Equation 1.2 into Equation 7,

$$P = \sigma A_0 e^{-\delta} \tag{8}$$

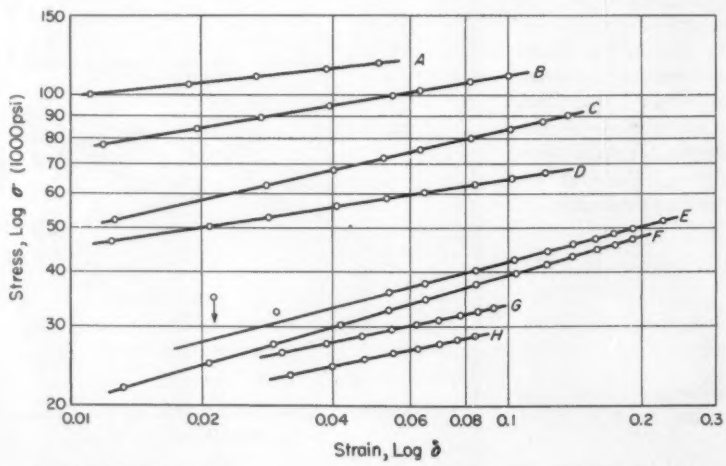


Fig. 2 — Logarithmic stress-strain curves for a number of different sheet materials.

Applying the "instability" or maximum load condition $dP = 0$ to Equation 8, it can be shown that

$$\frac{d\sigma_u}{d\delta_m} = \sigma_u \tag{9}$$

If the stress as given by Equation 3 is placed in Equation 9, then

$$\delta_u = n \tag{10}$$

That is, the true strain δ_u at the maximum load is equal to the strain hardening exponent. In other words, the strain hardening exponent can be used as a measure of *true ductility*. A survey of five investigations of 31 materials for which 180 true stress-strain relations were obtained shows that Equation 10 is a good approximation.[5] The average deviation between actual values δ_u and theoretical values n was found to be only two per cent.

True Toughness: An expression for the *true toughness T*, as measured by the shaded area in Fig. 1*b*, can be obtained if the true stress-strain relation of Equation 3 is used. That is, the area under the true stress-strain diagram to point B_1 in Fig. 1*b* is

$$T = \int_0^{\delta_u} \sigma d\delta \tag{11}$$

Placing $\sigma = k\delta^n$ in Equation 11, integrating, and noting that $\delta_u = n$, Equation 11 becomes

$$T = \frac{\sigma_u^{1+(1/n)}}{k^{1/n}(n+1)} = \frac{kn^{n+1}}{n+1} \tag{12}$$

A more accurate value of T could be obtained if Equation 5 were used for σ in place of Equation 11. However, the value of T given by Equation 12 is considered sufficiently accurate.

In the foregoing analysis it is shown that the plastic mechanical properties of materials in simple tension can be expressed in terms of the *true ultimate stress* σ_u, the *true strain at the maximum load* $\delta_u = n$, and the *true toughness* $T = k\,n^{n+1}/(n+1)$. That is, three material constants σ_u, k and n are necessary to define the true plastic mechanical properties.

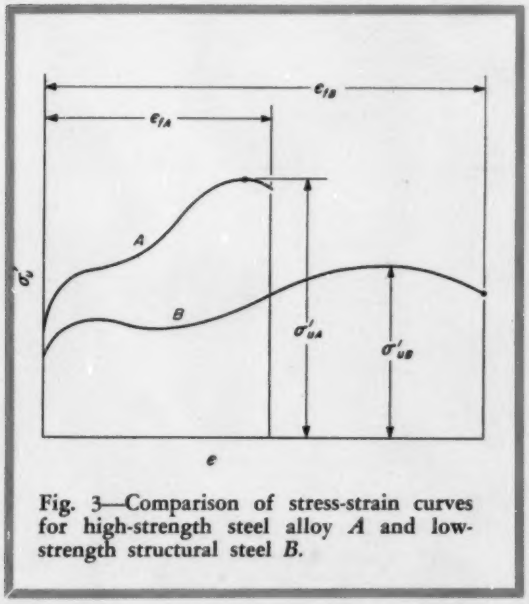


Fig. 3—Comparison of stress-strain curves for high-strength steel alloy *A* and low-strength structural steel *B*.

True stress-strain plastic properties can also be obtained for simple compression. Few relations have been reported, however, so that the validity of Equations 3 or 5 for simple compression has not been established.

In accepting true stress-strain measures of the plastic properties, it may be argued that these properties are only to be used in a qualitative way for selecting materials, and that for this purpose the usual nominal properties are adequate. This argument is, of course, incorrect since it is quite possible that a material selected on a basis of nominal properties will have a different rating than when selection is based on true properties.

Equations 3 or 5 can be used to obtain stress and deformation relations for members subjected to simple stresses, such as bending and torsion. These relations can then be used as a basis for the design of such members.

Design Stresses: Selection of a design or allowable stress is usually determined by dividing the yield stress σ_{yp} or the nominal ultimate stress σ'_u by an appropriate factor of safety. That is,

$$\sigma_w = \frac{\sigma_{yp}}{N_y} \tag{13.1}$$

or

$$\sigma_w = \frac{\sigma'_u}{N_u} \tag{13.2}$$

It is realized that these equations do not take into account the relative values of ductility. For example, consider two materials as shown in Fig. 3—one a high-strength steel alloy, *A*, and the other a low-strength structural steel, *B*. Then, according to Equation 13.2, if the same value of N_u is used, the working stresses for materials *A* and *B* are

$$\sigma_{wA} = \frac{\sigma'_{uA}}{N_u} \tag{14.1}$$

and

$$\sigma_{wB} = \frac{\sigma'_{uB}}{N_u} \tag{14.2}$$

In evaluating the working stresses, no provision is made for the fact that material *B* has a larger strain at fracture or at the ultimate load than material *A*. This larger plastic deformation gives material *B* an advantage over material *A* which is not reflected in Equations 14.1 and 14.2. To provide for this oversight and to give a more accurate quantitative measure of the working stress, a new method selecting this stress is suggested.

Referring to the true stress-strain diagram of a material, Fig. 4, four working stresses will be defined—two based on the yield stress and true

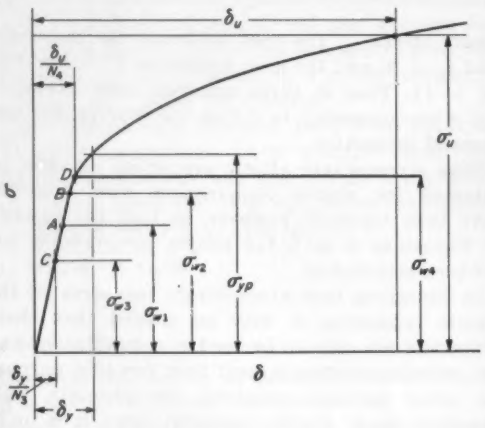


Fig. 4 — Selection of working stress for simple tension.

ultimate stress, and two based on the strain at the yield stress and the strain at the true ultimate stress. That is, referring to Fig. 4 and assuming the stress-strain relation defined by Equation 3,

$$\sigma_{w1} = \frac{\sigma_{un}}{N_1} \tag{15.1}$$

$$\sigma_{w2} = \frac{\sigma_u}{N_2} \tag{15.2}$$

$$\sigma_{w3} = \frac{E\,\delta_y}{N_3} \tag{15.3}$$

$$\sigma_{w4} = \frac{k}{N_4}(\delta_u)^n \tag{15.4}$$

Equations 15.1 through 15.4 define the four working stress values indicated by points *A*, *B*, *C* and *D*, Fig. 4. The governing working stress would then be the smallest of these stresses. In the case of Fig. 4, the stress selected would be σ_{w3} as defined by point *C*.

Selection of the factors of safety *N* in Equations 15.1 to 15.4 is based on many considerations. Various attempts have been made to provide a rational determination of the factor of safety.[6]

Combined Static Stresses

Many machine and structural elements are subjected to combined stresses rather than simple uniaxial stresses. That is, the state of stress for combined stresses may be expressed in terms of three principal stresses, Fig. 5*b*, in place of the uniaxial stress, Fig. 5*a*. The principal stresses act on three mutually perpendicular planes on an element. One of these stresses σ_1 is the maximum possible value of the normal stress, the other σ_3 is the minimum possible normal stress value for the point considered, and the third σ_2 is intermediate in value between σ_1 and σ_3.

Theoretical Plastic Stress-Strain Relations: If the principal strains in the direction of the principal stresses σ_1, σ_2 and σ_3 are δ_1, δ_2 and δ_3, then the mechanical properties for combined stresses can be obtained when the stress-strain relations to failure are known for each principal stress. It is apparent that there are many of these principal stress-strain relations since the relations depend upon the values of principal stress ratios σ_2/σ_1, and σ_3/σ_1. Some of these possible relations are indicated in Fig. 6. Owing to the difficulty of obtaining these relations experimentally, many attempts have been made to predict theoretically the principal stress-strain relations from the stress-strain relation in simple tension. [7-10]

For conditions in which the principal stress ratios remain constant during loading, the simple deformation theory has been found to provide a good approximation for defining the plastic stress-strain relations under combined stresses.[7] If the plastic stress-strain relation is defined by Equation 3 then the plastic principal stress-strain relations by the deformation theory[1] become

$$\delta_1 = (1/k)^{1/n}\,\bar{\sigma}^{(1/n)-1}\,(\sigma_1 - \sigma_2/2 - \sigma_3/2) \tag{16.1}$$

$$\delta_2 = (1/k)^{1/n}\,\bar{\sigma}^{1/n-1}\,(\sigma_2 - \sigma_3/2 - \sigma_1/2) \tag{16.2}$$

$$\delta_3 = (1/k)^{1/n}\,\bar{\sigma}^{1/n-1}\,(\sigma_3 - \sigma_1/2 - \sigma_2/2) \tag{16.3}$$

where

$$\bar{\sigma} = \sqrt{\tfrac{1}{2}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right]} \tag{17}$$

By the first of Equations 16, the biaxial $\sigma_1 - \delta_1$

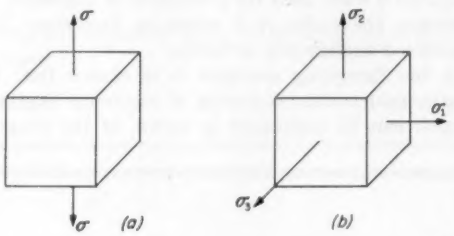


Fig. 5—Uniaxial and triaxial stresses.

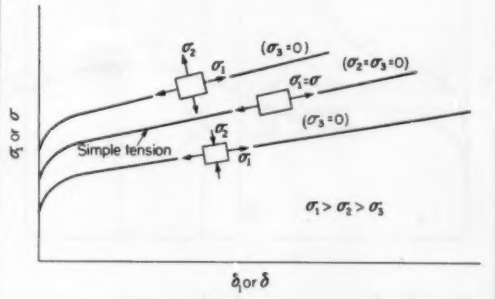


Fig. 6—Biaxial true stress-strain relationship.

relations shown in Fig. 6 can be determined from the simple tension relation. It should be noted that experimental verification of the theoretical stress-strain relations given in Equations 16 has been obtained for only a few materials and primarily for the biaxial states of stress shown in Fig. 6. This lack of experimental verification is understandable when it is realized that combined stress experiments are difficult to perform. In fact, for some stress combinations, suitable experiments have not been devised.

Mechanical Properties: A principal true stress-strain diagram for any stress combination as obtained by experiment is plotted in Fig. 7. Elastic strains δ_{E1} have been added to the plastic strains δ_1 to give the total strains δ_{T1}. That is,

$$\delta_{T1} = \delta_{E1} + \delta_1 = \frac{\sigma_1}{E} - \frac{\nu}{E}(\sigma_2 + \sigma_3) + \delta_1 \qquad (18)$$

Points *A*, *B* and *C* correspond to the yield stress, true ultimate stress (or stress at the maximum load or instability), and true fracture stress. These stresses are represented by the symbols σ_{1y}, σ_{1u} and σ_{1f}, respectively. The *yield stress* σ_{1y} can be determined by using an offset strain δ_{1p} equivalent to the offset strain used in simple tension.[11] The *true ultimate stress* σ_{1u}, corresponds to the maximum load as indicated by point B_1 where the slope of the $\sigma'_1 - \epsilon_{T1}$ diagram is zero. The *true fracture stress* σ_{1f} is not of practical significance since the parts *BC* or B_1C_1 of the stress-strain diagrams represent a region of changing state of stress produced by significant changes in dimensions.

ULTIMATE STRESS: True value of ultimate stress (at maximum load or instability) can be found for specific members and types of loading based on the deformation theory as defined by Equations 16. That is, the value of ultimate strength as measured by σ_{1u} can be obtained from Equations 16.1 provided that the value of σ_{1u} corresponding to δ_{1u} is known. That is, from Equation 16.1 the ultimate strength is defined as

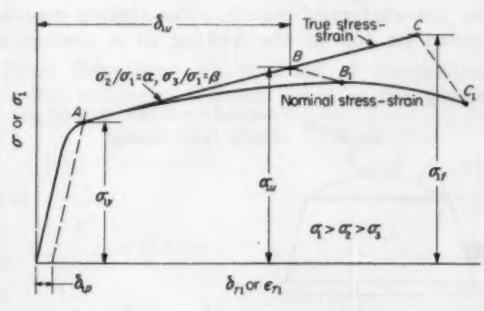


Fig. 7 — Comparison of biaxial true and nominal stress-strain relationships.

$$(\sigma_{1u})^{1/n}[1 + \alpha_2 + \beta_2 - \alpha - \beta - \alpha\beta]^{(1-n)/2n}\left[1 - \frac{\alpha}{2} - \frac{\beta}{2}\right] = \left(\frac{\delta_{1u}}{\delta_u}\right)(\sigma_u)^{1/n} \qquad (19.1)$$

The value of δ_{1u} depends upon the type of loading and member.[12-13] For example, in a thin-walled spherical shell subjected to internal pressure, using Equation 16.1, the theoretical value of $\delta_{1u} = \delta_{2u}$ can be shown to be $\delta_{1u} = n/3$. Placing values of $\delta_1 = \delta_{1u} = n/3$, $\sigma_2 = \sigma_{1u}$, $\sigma_1 = \sigma_{1u}$, $\sigma_3 = 0$ in Equation 16.1, it can be shown that

$$\sigma_{1u} = \left(\tfrac{3}{4}\right)^n \sigma_u \qquad (19.2)$$

where σ_u = true ultimate stress (at maximum load) in simple tension.

Most values of n lie approximately between $\frac{1}{8}$ and $\frac{1}{4}$. For these values the strength σ_{1u} is 0.95 σ_u and 0.91 σ_u, respectively. This corresponds approximately to the value of $\sigma_{1u} = \sigma_u$ which is obtained using most of the various strength theories.

YIELD STRESS: The values of yield stress obtained by determining the stress σ_1 from Equation 16.1 for a selected value of the offset plastic strain ϵ_1. That is, the strain δ_1 will be replaced by δ_{1p}, where δ_{1p} is the equivalent offset strain corresponding to the offset strain δ_p used for determining the yield stress in simple tension. Then by Equation 16.1, the yield strength for combined stresses is defined by

$$\left(\frac{\sigma_{1y}}{k}\right)^{1/n}[1 + \alpha^2 + \beta^2 - \alpha - \beta - \alpha\beta]^{(1/n)-1}\left(1 - \frac{\alpha}{2} - \frac{\beta}{2}\right) = \delta_{1p} \qquad (20)$$

The value of δ_{1p} selected will be based on the ratio of the strains δ_{1u} to δ_u for the particular principal stress ratio. That is,

$$\delta_{1p} = Q\,\delta_p \qquad (21)$$

where δ_p = the offset strain for simple tension, and $Q = \delta_{1u}/\delta_u$.

For the case of the thin-walled spherical shell subjected to internal pressure, $Q = \delta_{1u}/\delta_u = 1/3$, $\alpha = 1$, $\beta = 1$ and, by Equations 20 and 21,

$$\sigma_{1y} = k\,(2\,Q\,\delta_p)^n = k\left[2\left(\frac{\delta_{1u}}{\delta_u}\right)\delta_p\right]^n = K\left(\frac{2\,\delta_p}{3}\right)^n \qquad (22)$$

For a particular material, σ_{1y} can be determined from Equantion 22 since k, n and δ_p are known.

TRUE DUCTILITY: Measure of true ductility is the maximum normal strain corresponding to the maximum load or point of instability. Since σ_{1u} is the maximum stress, the maximum normal strain at instability or true ductility will be designated by δ_{1u}, Fig. 7. It is apparent that the value of δ_{1u} will depend upon the principal stress ratios $\alpha = \sigma_2/\sigma_1$ and $\beta = \sigma_3/\sigma_1$ and that these stress

ratios should be specified when values of δ_{1u} are given. Theoretical values of δ_{1u} can be found from Equation 16.1 for particular states of stress and members.[12-13] For example, for a thin-walled spherical shell under internal pressure, the strains at the maximum pressure are $\delta_{1u} = \delta_{2u} = n/3$.

TRUE TOUGHNESS: Measure of true toughness is obtained by evaluating the work done in a unit volume in stressing to the maximum load or point of instability as represented by the areas under the σ_1, σ_2 and σ_3 true stress-strain diagrams to the stress corresponding to the maximum load. A theoretical value of the true toughness can be obtained from Equation 16. Since the strain energy for the elastic range is usually small compared to that in the plastic range, it can be neglected. True toughness then becomes

$$T = \int_0^{\delta_{1m}} \sigma_1 \, d\,\delta_1 + \int_0^{\delta_{2m}} \sigma_2 \, d\,\delta_2 + \int_0^{\delta_{3m}} \sigma_3 \, d\,\delta_3 \qquad (23)$$

where δ_{1m}, δ_{2m} and δ_{3m} are the strains at the maximum load.

For loadings in which the stress ratios α and β remain constant, as indicated in Fig. 7, an approximate value of the true toughness can be determined by substituting values of δ_1, δ_2 and δ_3 from Equations 16.1 to 16.3 into Equation 23. Making these substitutions, it can be shown that

$$T = \left[\frac{\sigma_{1u}^{1/n+1}}{(n+1)\,k^{1/n}} \right] (1 + \alpha^2 + \beta^2 - \alpha - \beta - \alpha\beta)^{1+n/2n} \qquad (24)$$

Equation 24 gives a theoretical measure of true toughness for the case of triaxial stresses in which principal stress ratios α and β remain constant.

Discussion of simple and combined static stresses presented here has led to a new method for evaluating yield and ultimate strengths for combined states of stress. Basic to the method is the assumption that the true stress-strain relation for simple tension is expressed by Equation 3.

In the next article of this series, a number of conventional strength theories that are not based on the plastic stress-strain relation are reviewed, and a generalized theory of strength is proposed. These theories are used to develop working stress relations that can be used in design for combined static stresses and design for static-stress concentrations.

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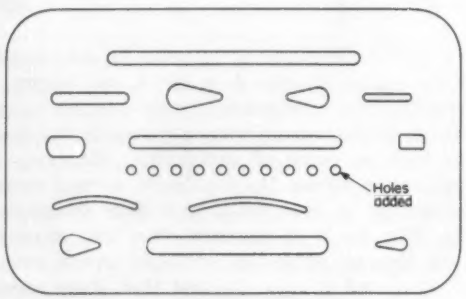
Tips and Techniques

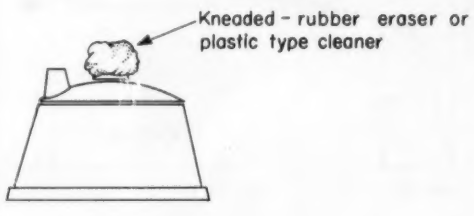
Modified Erasing Shield

Fairly often when drafting it becomes necessary to change a solid line to a dotted line. By placing a series of holes in an erasing shield as shown, it is possible to make the conversion simply by erasing through the holes.—REGINALD R. GALLANT, *Underwood Corp., Bridgeport, Conn.*



Pencil Point Cleaner

A ball of kneaded rubber eraser or plastic cleaner is very efficient for removing powdered graphite from just-sharpened pencils. The cleaner may be mounted on top of the locknut of a mechancal



pencil pointer or any other convenient place.—IRVING L. GREENSPAN, *Lockheed Aircraft Corp., Missiles Systems Div., Van Nuys, Calif.*

Calculus of finite differences offers a simplified numerical method for

Fitting Equations to Experimental Data

By A. Bruce Cox, *Pittsburgh*

FINDING an exact analytical relationship for experimental or laboratory data in tabular or curve form can be a demanding and time-consuming task. In most cases, particularly when the equation for a given set of data takes the form of a "power" expression, rapidity and accuracy of solution may depend on the experience, knowledge and mental processes of the analyst.

For such analyses, a powerful research tool is provided by a not very widely known branch of mathematics called the *calculus of finite differences*. Based on simple numerical principles, this graphical-mathematical process offers a rapid and accurate method of "equation-fitting." Basic techniques of the method and their application are outlined in this article.

Basic Principles: By methods of conventional calculus, successive differentiation of the general expression,

$$y = A + Bx + Cx^2 + Dx^3 \qquad (1)$$

gives:

$$\frac{dy}{dx} = B + 2Cx + 3Dx^2 \qquad (2)$$

$$\frac{d^2y}{dx^2} = 2C + 6Dx \qquad (3)$$

$$\frac{d^3y}{dx^3} = 6D \qquad (4)$$

This operation is actually a "stripping" procedure. First, the A term is stripped off and then the B term. Finally, when the C term is stripped off, all that remains is the constant, $6D$.

From the practical standpoint of technical data analysis, this "stripping off" of successive terms is more conveniently done by the calculus of finite differences. This method of analysis is peculiarly well adapted for finding the exact form of the relation of y to x when a definite, simple relation is inherent in the x and y data.

For example, consider an expression of the form given in Equation 1 in which $A = -10$, $B = -4$, $C = 0$ and $D = 1$. By substitution in Equation 1, then, this expression becomes

$$y = x^3 - 4x - 10 \qquad (5)$$

Corresponding values of x and y for Equation 5 can be readily determined by calculation. Several representative values are given in the two left-hand columns of Table 1; a plot of these values is shown in Fig. 1.

Assume now, for this example, that the foregoing conditions are reversed as they would be in an actual research situation. That is, the only data available on the relationship between x and y are those given by Table 1 and the curve plot in Fig. 1. Values of the constants A, B, C and D (Equation 1), which were assigned previously to establish the exact relationship given in Equation 5, are not known. These constants will now be determined using the calculus of finite differences.

It will be noted that the differences between

Table 1—Data for Curve Plot Analysis

x	y	Δy	$\Delta^2 y$	$\Delta^3 y$
0	−10.000			
		−1.875		
0.5	−11.875		+0.75	
		−1.125		+0.75
1.0	−13.000		+1.50	
		+0.375		+0.75
1.5	−12.625		+2.25	
		+2.625		+0.75
2.0	−10.000		+3.00	
		+5.625		+0.75
2.5	− 4.375		+3.75	
		+9.375		
3.0	+ 5.000			

consecutive values of x in Table 1 are equal. This is essential. But surprisingly, the size of these increments (Δx) need not be small. In fact, in the anaysis of laboratory data, the increment should not be so small that the numerical values of small errors unavoidable in all laboratory measurements are a large percentage of the increment value. However, in this particular "made-up" problem, there are no errors. The increment of x can be taken small or large, as suits the convenience of the analyzer.

First step in the analysis of the x and y data of Table 1 is to find the differences, Δy, between consecutive values of y. These Δy values are listed in the third column of Table 1, opposite the cor-

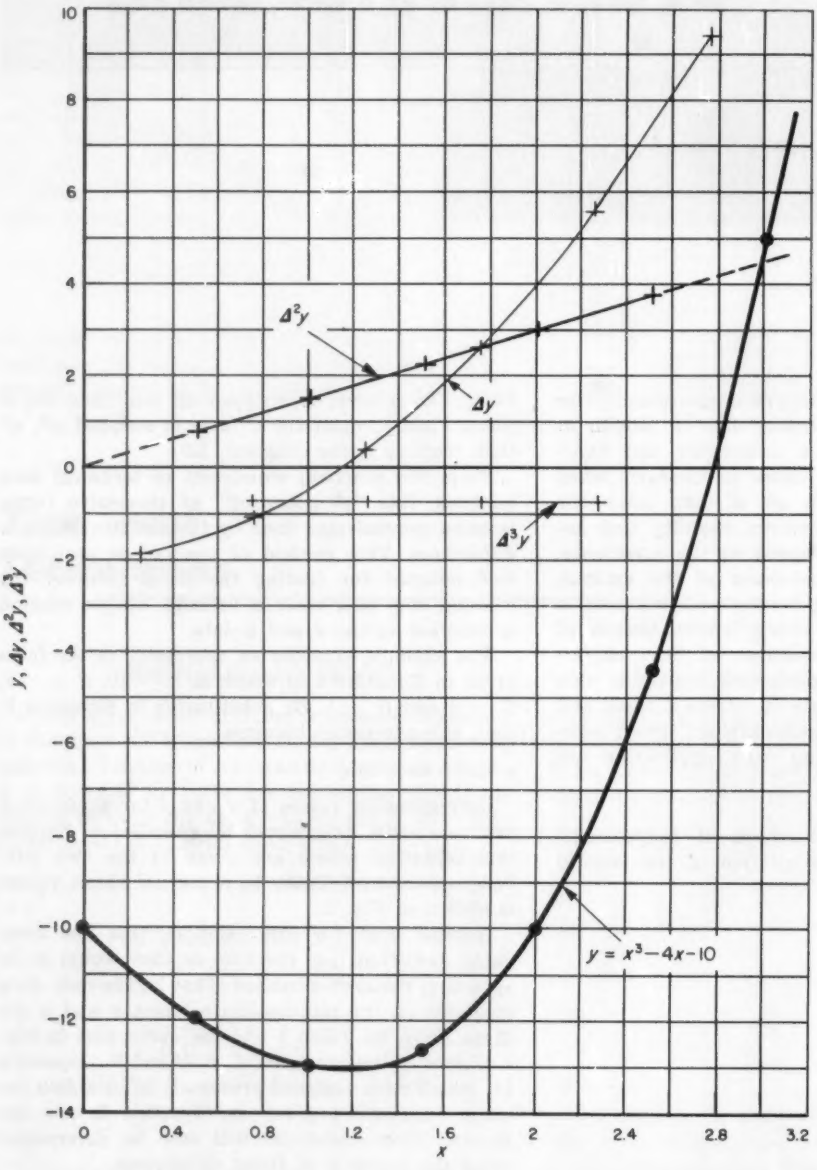


Fig. 1 — Basic curve plots for analysis of Equation 5 by calculus of finite differences. Data for equation and "difference" curve plots are given in Table 1.

responding intermediate spaces between the horizontal lines on which the values of x and y appear.

Second, the differences, $\Delta^2 y$, between consecutive values of Δy are tabulated. These $\Delta^2 y$ values, which appear in the fourth column of Table 1 are located on the same horizontal lines as the x and y values.

Third, the differences, $\Delta^3 y$, between consecutive values of $\Delta^2 y$ are tabulated. These values are listed in the right hand column of Table 1 on the same lines with the Δy values.

For convenience, in Table 1 only the values of Δy, $\Delta^2 y$ and $\Delta^3 y$ have been used. In the calculus of finite differences, however, the expressions corresponding to those of Equations 2, 3 and 4 actually take the form:

$$\frac{\Delta y}{\Delta x} = B + 2Cx + 3Dx^2 \qquad (6)$$

$$\frac{\Delta^2 y}{\Delta x^2} = 2C + 6Dx \qquad (7)$$

$$\frac{\Delta^3 y}{\Delta x^3} = 6D \qquad (8)$$

The value of constant D can be determined from the data in Table 1, using Equation 8. Substituting the values of $\Delta^3 y = 0.75$ and of the increment of x, $\Delta x = 0.5$, into this equation gives the exact solution:

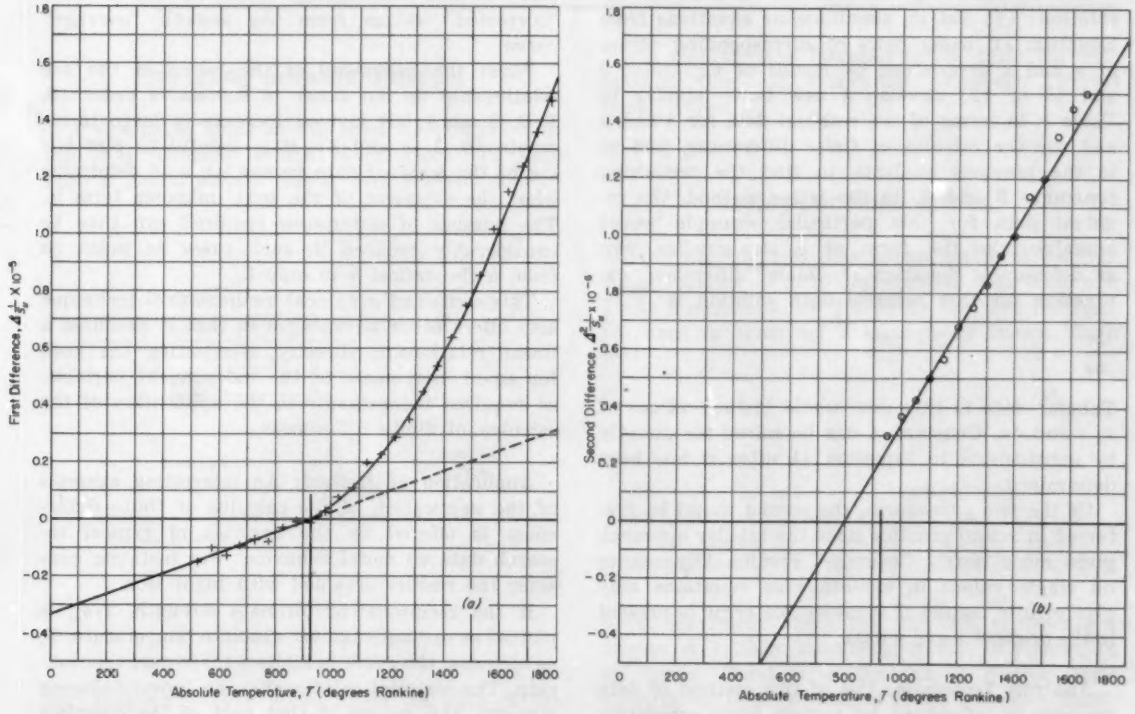
$$D = \frac{0.75}{6(0.5)^3} = 1.0$$

A similar approach can be used to determine constant C from Equation 7. In this case, it will be noted that the relationship between corresponding values of $\Delta^2 y$ and x, Table 1, takes the form of a straight line curve when plotted, Fig. 1. Since this is a linear relationship, any pair of $\Delta^2 y$ and x values may be chosen from Table 1 to calculate constant C from Equation 7. The following values will be used here: $x = 2.0$, $\Delta^2 y = 3.0$. From Equation 7 then, using the value of D just calculated, the exact solution is:

$$C = \frac{\frac{3.0}{(0.5)^2} - 6(1.0)(2.0)}{2} = 0$$

For calculation of constants A and B, however, a modified approach will have to be employed. By plotting values of Δy and x, Fig. 1, it will be seen

Fig. 2—"Difference" curves for analysis of relationship between absolute temperature and reciprocal value of tensile strength for ingot iron. First-difference curve at *a* shows relationship between 70 and 470 F (530 and 930 R) to be of second-power polynomial form. Second-difference curve at *b* shows relationship to be of third-power polynomial form from 470 F to melting point.



that a linear relationship does not exist. The appropriate values of x for this comparison are the intermediate values, half-way between those given in the table: $x = 0.25$, $y = -1.875$; $x = 0.75$, $y = -1.125$; etc.

Thus, the data given in Table 1 cannot be used directly (Equation 6) to find constant B as they were in the solutions for D and C. However, determination of the numerical values of constants A and B is no longer a serious problem.

Suppose that the C and D terms were not already known to be second and third power exponentials. The fact that the tabulation for $\Delta^3 y$ in Table 1 resulted in a series of equal values would have proved this condition to exist and, also, that the A and B terms have exponents of 0 and 1.

With the data now available, numerical values of the individual D and C terms can be calculated for each value of x in Table 1, and subtracted, or "stripped off," one at a time (or simultaneously) from the original y values, thus leaving residual data in the form of

$$r = y - Dx^3 \tag{9}$$

$$s = r - Cx^2 \tag{10}$$

These sets of residual data can be treated as entirely new data to find constants A and B. Basic equation for this solution is an alternate expression for s which can be readily derived from Equation 1:

$$s = A + Bx \tag{11}$$

Two alternative procedures can be used for the solution: (1) Set up simultaneous equations from Equation 11, using pairs of corresponding values of s and x determined by means of Equations 9 and 10 or (2) develop a new table, similar to Table 1, in terms of the residual data for s and x and use the calculus of finite differences, just as in the previous analysis, to find the remaining constants B and A. In the latter method, the residual data for this particular example would actually take the form of a straight-line plot as defined by Equation 11. Basic "difference" expression for this residual data solution is:

$$\frac{\Delta s}{\Delta x} = B \tag{12}$$

Tabular data in this case would include values of x, s and Δs. Constant A can be solved for directly by substitution in Equation 11 after B has been determined.

Of the two procedures, the second would be preferred in actual practice since the tabular approach gives more nearly "average" results. Dependence on single values in simultaneous equations may give erratic results if considerable error is present in the original x and y data.

Analysis Technique: Use of this method of data analysis is influenced by certain basic considerations.

If a relationship of the general type defined by Equation 1 is inherent in the data, as is the case in much of the properly measured engineering and scientific data, this method of analysis by the calculus of finite differences will give the exact form of the equation and determine the exponents and the numerical values of the constants of the different terms. Naturally, it is not necessary to know beforehand any of these details of the relations between the two variables being investigated.

One essential precaution needs to be kept constantly in mind in the use of this method: The "nature" of the relations between the two variables under investigation must not change throughout the entire range for which measurements are made. This disqualifies a great deal of conventional data. For example, in pressure-volume (P-V) measurements for solids, the relation of P and V usually changes from a nonflowing, nonplastic one to that of a flowing plastic solid. No consistent relation can be expected from a test of such varying "nature."

There are also some other practical points to be observed in applying the calculus of finite differences to technical data. This method is a very sensitive one and, therefore, needs to be applied with a lot of common sense. Usually, after two or, at the most, three differences have been taken for y, the unavoidable (small) errors in the measured data are more than enough to obscure any further significance the x and y relation might be expected to have. This is all the more true when the errors show a trend. To "average out" heterogeneous errors, it helps to replot the residual data after every second differencing operation and to read "corrected" values from the smooth "average" curve.

When the exponents of the terms in the x-y relationship do not occur in successive order (0, 1, 2, 3, etc.) but instead increase in large increments (0, 1, 4 and 8), it is helpful to plot the log of the residual data versus log x to determine what the exponent of the next unknown term is. The number of differences required can thus be considerably reduced in such cases as much as from a theoretical 8 to only 2.

This combined graphical-mathematical technique also offers other advantages in that it produces a linear relationship directly, eliminating the need for equal increments of the independent variable, as required theoretically in the application of the calculus of finite differences.

Application of Method: An interesting example of the application of the calculus of finite differences is offered by the analysis of typical research data on metal behavior. For instance, consider the results obtained with ingot iron.

If the reciprocal of ultimate strength, $1/s_u$, is plotted as ordinate against absolute temperature, T, as abscissa, the curve exhibits a three-part relationship. The simplest relationship, an upward-sloping straight line, occurs in that part of the complete curve between absolute zero and about 70 F

(530 Rankine). An abrupt shift in the relation occurs at 70 F, with the curve turning mildly downward, supposedly due to a change in the structure of the metal.

The relation of $1/s_u$ to T continues smoothly downward from 70 to 470 F (930R) where another change in atomic structure reverses the relationship and turns the curve upward again, this time very sharply. This trend continues to the melting temperature of the metal.

The relationship of s_u to T in the first part of the curve plot obviously takes the form

$$\frac{1}{s_u} = A + \frac{B}{T} \qquad (13)$$

where A and B are constants.

For the second and third parts of the curve, the calculus of finite differences will be applied to find the form of relationship. Because of data measurement limitations, it will not be worthwhile to use extreme refinement in applying this method.

A plot of "first difference" $\Delta(1/s_u)$ versus T is shown in Fig. 2*a*. The resulting straight line for the second part of the curve (70 to 470 F) shows the relationship here to be

$$\frac{1}{s_u} = A + \frac{B}{T} + \frac{C}{T^2} \qquad (14)$$

where A, B and C are constants.

A plot of "second difference" $\Delta^2(1/s_u)$ versus T is shown in Fig. 2*b*. The straight line appearing here establishes the relationship for the third part of the curve (470 F to melting point) to be of the form,

$$\frac{1}{s_u} = A + \frac{B}{T} + \frac{C}{T^2} + \frac{D}{T^3} \qquad (15)$$

where A, B, C and D are constants.

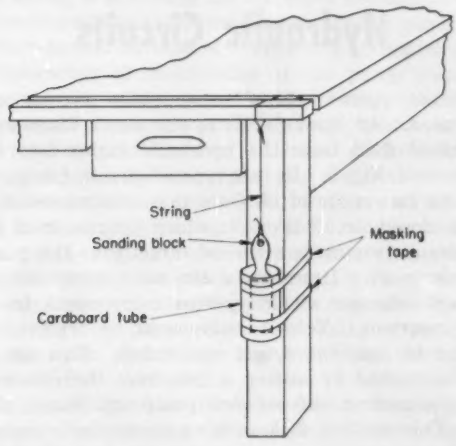
Since it might be assumed that Equations 14 and 15 are merely simple types of "infinite series" with exponents increasing in increments of one for each successive term, it should perhaps be pointed out that this is not always true. For pressure-volume relationships in gases and vapors, for example, the exponents are always in the order 0, 1, 4 and 8. Still different variations in exponents are common in other cases.

In such "natural" (nonempirical) relations as these, it will be seen that the "differencing" operation ends itself abruptly. It does not continue on and on indefinitely with smaller and smaller residual data left over. In data where the relationship has not been restricted to that existing between two variables only, the relation is empirical and endless differencing is likely to result. The differencing can then be repeated until the residual data, as indicated by deviation from a straight line, is as small as the analyst may desire.

Tips and Techniques

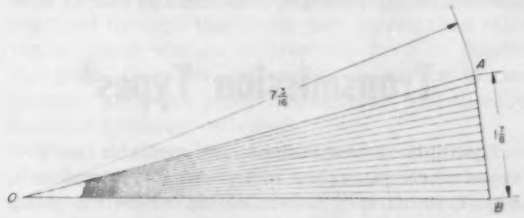
Preventing Graphite Smudges

A sandpaper block or file used for pencil pointing is a potential source of smudges. To keep such a pencil pointer handy and prevent smudging, suspend it by a string from the edge of the drafting table so it hangs inside a section of cardboard mailing tube fastened to the table leg with masking tape.—R. WOLFARTH, *Goodyear Aircraft Corp., Akron, O.*



Laying Out Small Angles

Remembering two dimensions makes it easy to lay out angles up to 15 degrees with high accuracy. These dimensions are 7 3/16 in. and 1⅞ in. They are used to construct a triangle as shown. Each



⅛-in. increment along the line AB represents 1 degree. A 1/16-in. increment would, of course, be ½ degree. Total error for the 15 degree angle constructed by this method is 41 seconds.—REINHOLD J. KOCH, *Read Standard Corp., York, Pa.*

Basic factors in

Adjustable-Speed

By Louis G. Jordan,
Assistant Chief Engineer
Industrial Products
Vickers Inc., Detroit

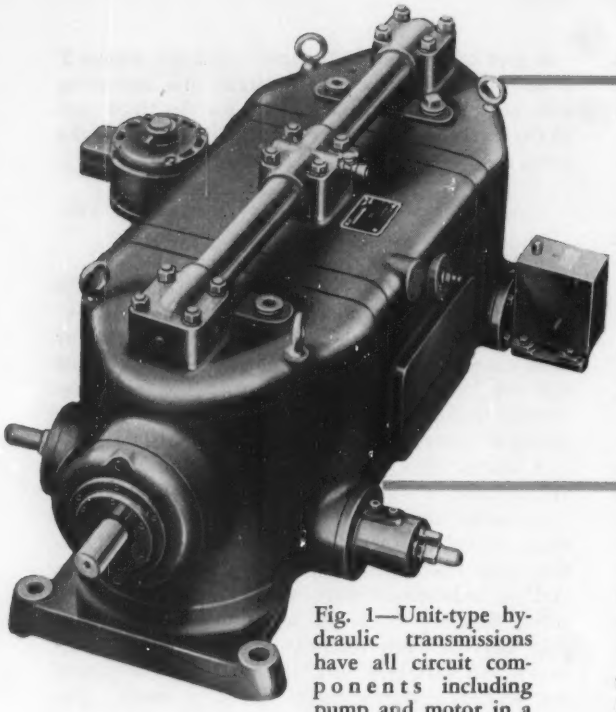


Fig. 1—Unit-type hydraulic transmissions have all circuit components including pump and motor in a single housing.

ADJUSTABLE-speed hydraulic transmissions are an excellent means for converting a constant-speed rotary motion into a controlled rotary motion which can be easily adjusted over a range of speeds. A simple constant-speed prime mover used in combination with a hydraulic transmission produces an adjustable-speed drive capable of use in high-torque applications with heavy or light loads without danger of overloading the prime mover.

Basic components of an adjustable-speed hydraulic transmission are a power source, suitable controls and a fluid motor. The power source usually includes the primary source of input power, hydraulic pump, strainers, filters and fluid reservoir. The source of input power may be an electric drive motor or, in some cases, the machine drive itself. Hydraulic controls consist of valves for controlling pressure, direction and rate of flow.

Transmission Types

Hydraulic transmissions are available as unit types where pump and motor are an integral unit, Fig. 1, or as split transmissions where the pump is separated from the hydraulic motor. Because the fluid motor can be located some distance from the pump, the split type permits installation where available space and physical arrangement of the hydraulic system preclude the possibility of using a transmission of unit construction. In a system utilizing a split transmission, as in any oil-hydraulic system, piping runs connecting the pump, motor and controls should be kept as short and free of bends as possible.

Variable-speed hydraulic transmissions may also be classified according to output shaft rotation; i. e., a transmission may be capable of but a single direction of output rotation or may be reversible. Reversing action of the fluid motor may be accomplished by means of directional valving between pump and motor, or by use of a reversible pump capable of producing flow in either direction. The two-direction pump method generally produces smoother reversals, permitting sinusoidal acceleration and deceleration characteristics.

Pumps and fluid motors used in variable-speed hydraulic transmissions may be of gear, vane or piston type. Pump flow reversal is limited to the vane and piston types.

Hydraulic Circuits

Either open or closed transmission circuits may be used. An open circuit is one which discharges exhaust fluid from the hydraulic motor into the reservoir, Fig. 2. In this type of circuit, the pump draws its supply of oil from the same reservoir.

A closed circuit is one in which exhaust from the hydraulic motor is returned directly to the pump intake port. Drain lines are used to return internal leakage within system components to an oil reservoir. This leakage must be replaced in order to keep the closed circuit full. This can be accomplished by adding a line from the reservoir to the suction line between pump and motor, Fig. 3. This method is known as atmospheric replenishing in that atmospheric pressure is utilized for pushing the make-up oil into the pump intake.

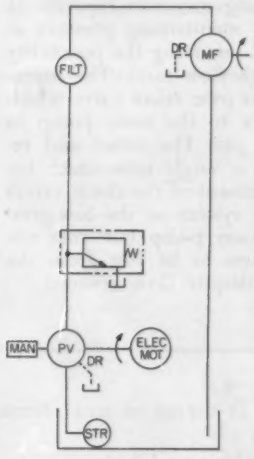
Replenishing can also be accomplished by super-

selecting and applying

Hydraulic Transmissions

Transmission Types
Hydraulic Circuits
Pump and Motor Selection
Control Types
Typical Applications

Fig. 2—In the open-type transmission circuit, hydraulic fluid is discharged from the fluid motor into a reservoir or tank. The pump draws its supply of oil from the tank.



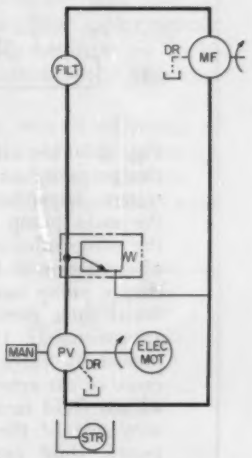


Fig. 3—In a closed-type transmission circuit the fluid motor discharges directly to the pump inlet. Because of leakage losses, a small reservoir is included in the system.

charging. Supercharging is the addition of a low-pressure fluid supply to the system by means of a small supercharging pump. This pump supplies make-up oil and at the same time insures a specified, predetermined minimum pressure at the main pump inlet port, permitting higher fluid velocities through the suction side of the pump without danger of cavitation. Supercharge pressure is usually 50 to 150 psi. Volume delivered by the supercharging pump need only be sufficient to slightly exceed that lost due to primary transmission system leakage.

Where other than piston-type pumps are used in a hydraulic transmission, an open circuit is generally selected. Choice of an open or closed circuit when a piston-type pump is used depends upon many things. Where high performance is required of the units selected, it is generally advisable to employ a closed circuit. The closed circuit also permits use of a reversible pump as the means of obtaining a reversing circuit when required. The open circuit has in its favor simplicity and generally cooler operation than a comparable closed circuit.

Operating characteristics of the pump also influence the choice of circuits. Where there is danger of reduced pressure at the pump intake port causing cavitation, a closed circuit should be used and a supercharge pump included.

It is sometimes possible to effect a cost saving by using a supercharged system which permits use of a smaller, less expensive piston pump. Higher intake velocities achieved with a supercharged system usually permit use of a pump which is one size smaller than would be required in an open circuit system delivering the same power. For example, a piston pump nominally rated at 50 gpm at rated speed with atmospheric pressure intake may be capable of delivering as much as 72.5 gpm when used in a supercharged circuit, an increase of nearly 50 per cent.

This increased delivery results from the use of more of the inherent pump capacity by pushing the fluid through the intake port rather than relying on pump suction to draw the fluid in. Supercharging, therefore, represents a means of increasing allowable pump displacement and thereby increasing volume delivered.

Where a reversible pump is used to achieve two directions of transmission output shaft rotation, a closed circuit must be used to permit interchange of pump inlet and outlet ports. Closed circuits also permit use of a very small pump for supercharging, because it need only deliver an amount of oil that is slightly in excess of total system leakage. In order to supercharge the main pump inlet in an open circuit, the supercharge pump ca-

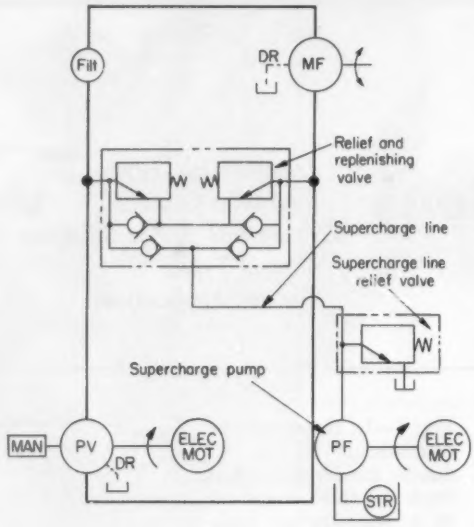


Fig. 4—This circuit incorporates a supercharge pump and a reversible replenishing system. Supercharging increases capacity of the main pump by maintaining pressure at the pump inlet and removing the possibility of cavitation at high flow rates. The supercharge pump has its own relief valve which limits inlet pressure to the main pump to approximately 150 psi. The relief and replenishing valve is a single unit which because of the arrangement of the check valves admits fluid to the system on the low-pressure side of the main pump but does not permit fluid pressure to be lost from the high-pressure side despite flow reversal.

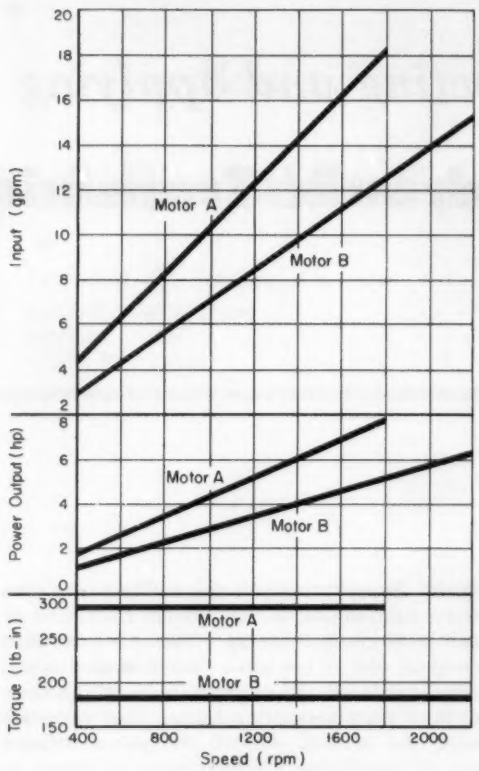


Fig. 5—Typical vane hydraulic motor performance curves for 1000 psi inlet pressure with oil having 150 ssu viscosity at 100 F operating at 120 F.

pacity must be a little in excess of total demand at the main pump inlet.

In a reversing adjustable-speed hydraulic transmission circuit, either pump line may be the intake side. Provision must, therefore, be made for a replenishing arrangement which will also be reversible, Fig. 4. In this reversible replenishing circuit, Fig. 4, the setting of the supercharge line relief valve and its location with regard to the variable-displacement pump, determine the adequacy of fluid pressure at the pump inlet. Recommended supercharge pressure is normally 150 psi measured at a point in the inlet line 4 or 5 ft from the pump intake port. Length and size of pipe between the supercharge relief valve and the pump inlet must be taken into account when designing a supercharging circuit. Relief valve setting must be sufficiently in excess of 150 psi to allow for pressure drop in the pipe.

Pump and Motor Selection

Specified horsepower, torque, speed, efficiency, operating pressure, space and weight limitations, life expectancy and cost factors must, of course, all be considered when selecting pumps and motors. Vane and gear pumps and motors have the following factors generally in their favor:

1. They are less costly than piston type units of comparable capacity.
2. Because of their relatively high slippage characteristics, they have good shock absorption abilities and can be used satisfactorily in low-efficiency circuits involving high-frequency cycling.
3. They are of more simple construction than piston types and are, therefore, more easily understood and serviced by maintenance personnel.

Recommended minimum speed for general applications of vane type units is usually about 100 rpm for motors and 600 rpm for pumps with maximum varying from 2200 to 1200 rpm depending upon pump or motor size. Where a lower motor-speed range is desired, it is generally advisable to use a speed-reducer take-off from the fluid-motor shaft. The motor can then operate at a higher, more desirable speed. Use of a speed

reducer also lessens the required torque at the motor in proportion to the reduction ratio and frequently permits use of a smaller unit.

Potentially serious bearing loads can be produced in vane units by normal hydraulic pressures. To minimize the effect of such loads, vane motors and pumps should be of hydraulically balanced construction. Recommended operating pressures for circuits in which vane-type fluid motors and pumps are used are generally lower than those employing piston units.

For vane-type equipment, actual running torque usually approximates 90 per cent of theoretical torque, with starting torque about 90 per cent of running torque. Overall efficiency depends upon operating pressure, speed, fluid characteristics, and other factors, but can generally be said to average about 70 to 80 per cent for recommended conditions of operation. Typical vane motor performance curves are shown in Fig. 5.

Where torque, efficiencies and permissible operating pressures are adequate to meet requirements, selection of other than a piston-type motor will usually produce some savings in cost. If greater torque, higher operating pressures or better efficiency are required, piston-type motor and pump are normally selected.

Commercially available standard piston units are capable of direct output torque up to 567,000 lb-in. Full-load torque can be delivered at very low speeds. Successful applications have been made at full-load operating speeds of less than 1 rpm. Maximum recommended speed is 3600 rpm for smaller sizes, 400 rpm for the largest size units.

For piston-type equipment, actual running torque usually approximates 95 per cent of theoretical torque, with starting torque about 95 per cent of running torque. Volumetric efficiency is a function of operating pressure and fluid viscosity. Losses are the result of leakage, fluid compressibility and pump structure deflection. Combined losses may run about 1 per cent for each 1000 psi of operating pressure. Thus a piston motor operating at 3000 psi can generally be expected to be within 97 per cent of calculated speed based on theoretical displacement.

As is true of other types, overall efficiency of piston units depends upon operating pressure, speed, fluid characteristics, and other factors; it generally approximates 80 to 90 per cent when

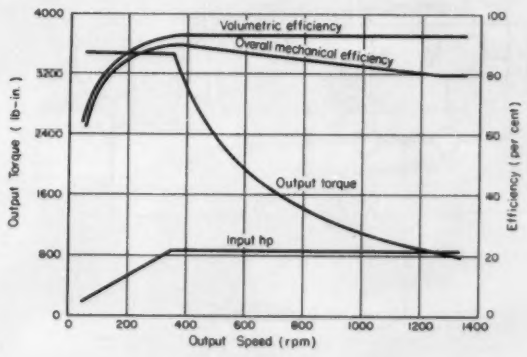


Fig. 6—Performance curves for a typical piston-type hydraulic motor. Overall efficiency is in the range of 80 to 90 per cent.

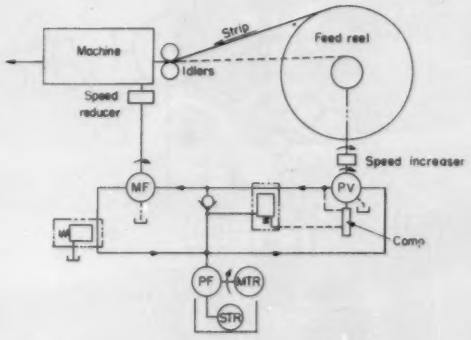


Fig. 7—This hydraulic transmission incorporating a variable-displacement pump and fixed-displacement motor serves as a tensioning brake on a strip-mill feed reel.

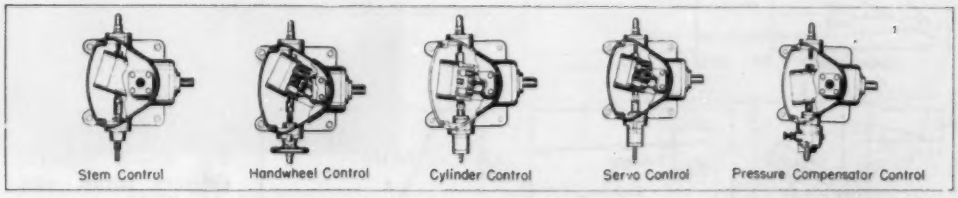


Fig. 8—Basic control arrangements available with standard models of piston type pumps and motors. Stem and servo arrangements can be used with a variety of manual or mechanical control linkages. The handwheel control is for manual adjustment only. The cylinder control permits a pilot valve to be used as a selector for either of two adjustable delivery rates. The pressure compensator control device is a purely hydraulic mechanism.

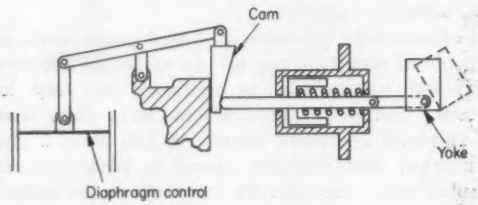


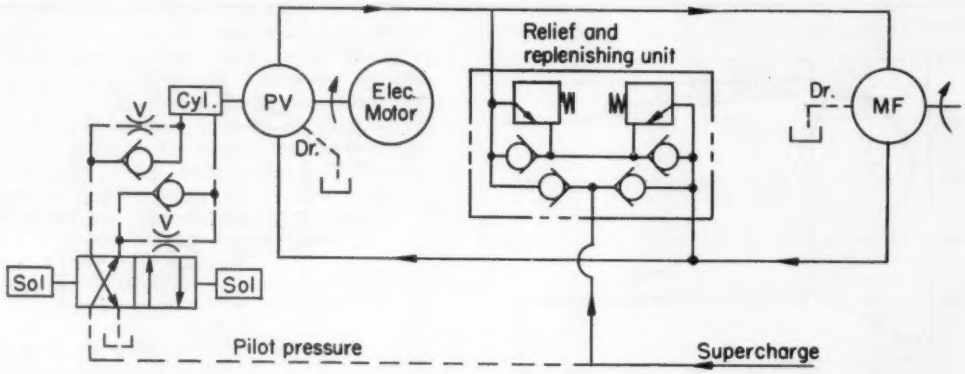
Fig. 9—Above—One of the possible variations possible when using mechanical control of pump or motor displacement is illustrated here. A diaphragm is used to control the position of a cam whose contour is translated into a change in pump or motor displacement by a push rod connected to the yoke of the pump or motor.

Fig. 10—Below—When cylinder control is used to obtain two different displacement positions of a variable-displacement pump or motor, it is advisable to control the rate of displacement change. In this circuit, two flow-control valves are used to restrict flow from the pump-control cylinder and thus control acceleration and deceleration of the motor.

piston pumps and motors are operated within the range of recommended conditions. A curve of overall efficiency is plotted in Fig. 6 for a typical piston-type hydraulic motor. Overall efficiencies for the entire drive where a piston-type pump and a piston-type motor are combined may be as high as 85 per cent.

Example: To illustrate the procedure involved in selection of a pump and fluid motor for use in an adjustable-speed hydraulic transmission, selection of these components for a strip-mill pay-off reel, Fig. 7, will be considered. In this application, the transmission is not actually a drive. It is a tension-controlling device. The strip mill pulls the reel, the reel drives the pump, the pump drives the fluid motor and the motor output is fed back to the strip mill. The transmission, therefore, serves as a brake.

First step is an analysis of drive requirements. The pay-off reel has a core diameter of 10 in. and a 40-in. maximum diameter. The strip pays off the reel into a machine whose speed is adjustable to provide strip speeds within the range of



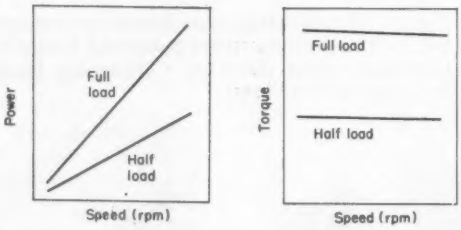


Fig. 11—Left — Horsepower and torque curves show the virtually constant-torque and variable-horsepower available from a hydraulic transmission which utilizes a variable-delivery pump and a constant-displacement fluid motor.

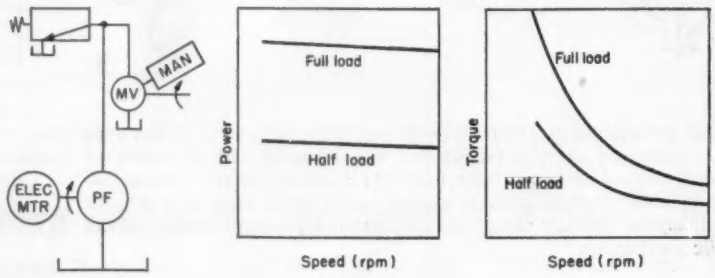


Fig. 12—A constant-delivery pump, variable-displacement motor combination produces nearly constant power with torque output decreasing as speed increases.

50 to 200 ft per min. Tension on the strip should be adjustable between 100 and 300 lb.

Reel speeds at high and low strip speeds for major and minor drum diameters are first calculated to determine pump speed:

$$R = \frac{12S}{\pi D}$$

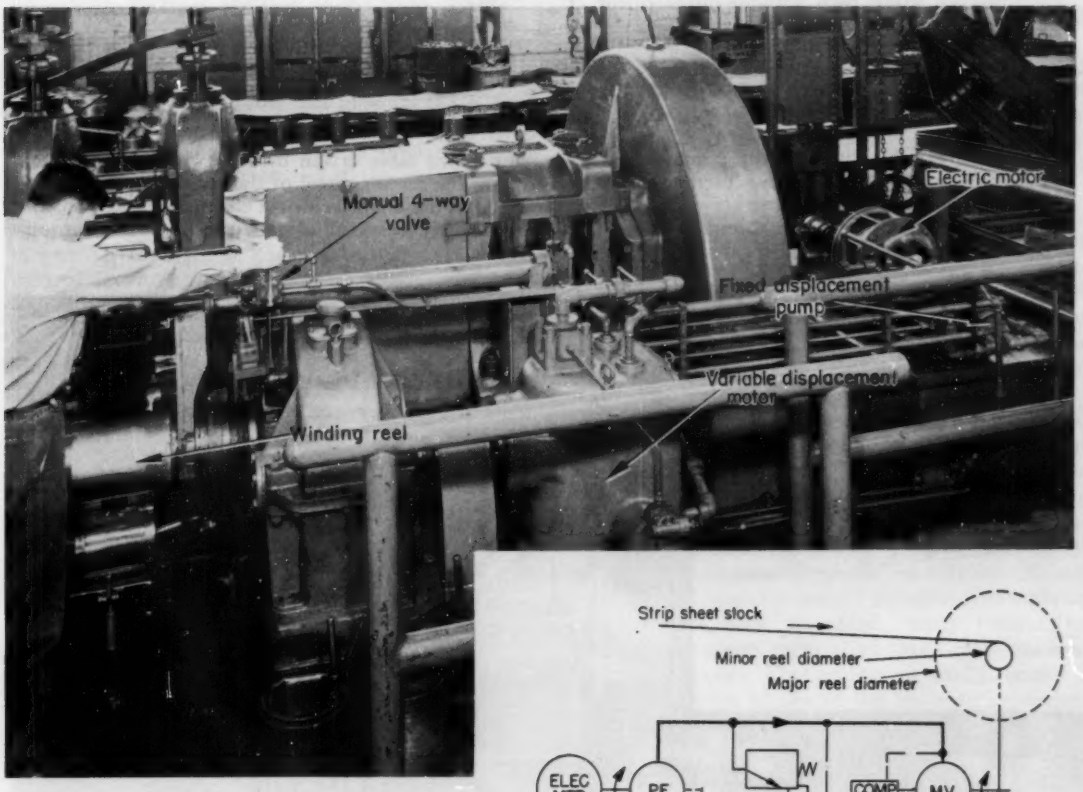
where R = reel speed, rpm; S = strip speed, fpm; and D = reel diameter, in. Speeds of 76.4 rpm and 4.8 rpm are found to be maximum and minimum. However, this minimum speed is too low for satisfactory control. A speed increaser with a 15:1 ratio is employed, therefore, to increase minimum pump speed to 72 rpm and keep maximum speed to an acceptable figure of 1146 rpm.

Torque required at the reel to maintain required tension must also be computed:

$$T = \frac{WD}{2}$$

where T = torque, lb-in.; W = strip tension, lb, and D = effective reel diameter. Maximum and minimum torques are found to be 6000 and 500 lb-in., respectively. These figures are modified by the ratio of the speed increaser and an assumed efficiency of 90 per cent for the speed increaser to 360 and 30 lb-in.

Pump size selection is based upon the maximum torque requirement and operating pressure which are directly proportional. Catalog data on fluid motors include torque per unit pressure and are used to select a pump providing the required torque at desired pressure. That is, a motor fitting the requirements is first selected and then a pump with equal displacement per revolution is chosen. In this case 1000 psi is chosen for maximum pressure and leads to a fluid motor with a theoretical torque rating of 383.5 lb-in. per 1000 psi or a pump delivering 2.41 cu in. per rev. Assuming that actual torque is 95 per cent of theoretical shows that actual maximum operating pressure



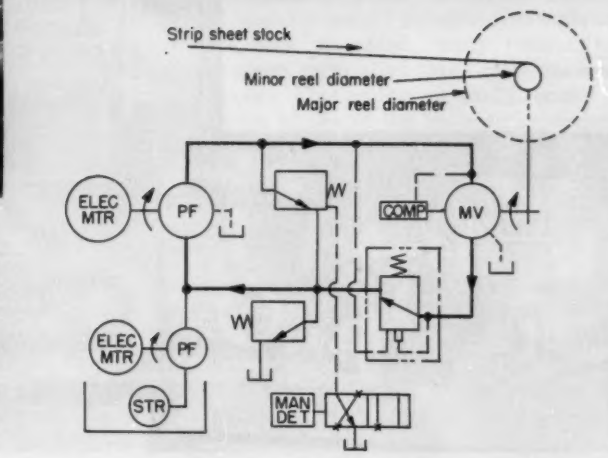


Fig. 13—A constant-displacement pump, variable-displacement motor transmission is used in this strip-mill coiling drive to automatically decrease speed and increase torque as the effective reel diameter increases because of strip buildup. Pressure compensator control of the motor produces this result by increasing the pump displacement per revolution to maintain constant pressure.

will be 895 psi from

$$P = \frac{1000TE}{K}$$

where P = pressure, psi; T = torque, lb-in.; E = efficiency, and K = torque per unit pressure, lb-in. per 1000 psi.

Control means for the pump or motor as well as speed-torque characteristics of the transmission are based upon load characteristics. For this application reel diameter decreases as reel speed increases and the torque requirement decreases at a rate proportional to the reduction in reel diameter. This is a constant-horsepower requirement which is met by a variable-displacement pump, fixed-displacement motor combination. A pressure-compensating control will automatically maintain the required constant flow and pressure despite variations in shaft speed and torque.

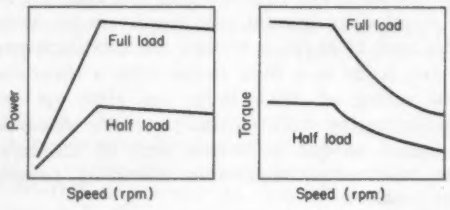


Fig. 14—Output characteristics of hydraulic transmissions using both variable-displacement pump and variable-displacement motor.

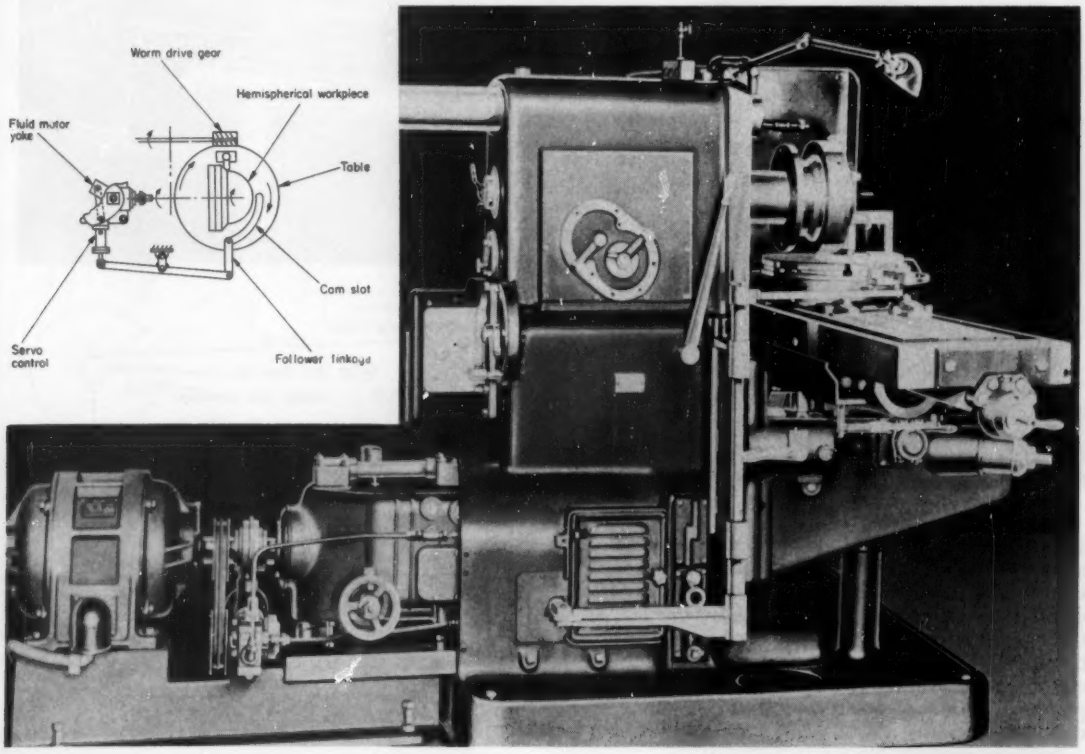
Fluid motor for this tension-control system is selected to have slightly less displacement than the pump will supply. This guarantees the pump will always exert tensioning torque on the reel. Since low speeds are most critical, the low end of the speed range is used to determine the required displacement from

$$Q = Rd_p$$

where Q = flow, cu in. per min; R = pump shaft speed, rpm, and d_p = pump displacement, cu in. per rev. This flow rate for the example is 690 cu in. per min. Since the pump must also supply leakage losses in the various system components, this figure should be reduced approximately 20 per cent to get a reasonable approximation of actual oil delivery to the motor. This rate is 552 cu in. per min.

In selecting a fluid motor to accept 552 cu in. per min, it is most economical to select as small a motor as possible consistent with displacement

Fig. 15—A variable-displacement pump, variable-displacement motor transmission is used on this milling machine to provide an extremely wide range of speed variation combined with automatic control of surface cutting speed on a spherical surface. A cam slot in the table driven by the hydraulic motor actuates the servo control of the motor to vary motor speed as the diameter of cut changes and thus maintain nearly constant surface speed of the cutting tool.



requirements and maximum recommended speed. A motor having a displacement per revolution of 0.76 cu in. fulfills this requirement and operates at speeds of 180 to 730 rpm. A speed reducer or increaser may then be used to connect the motor shaft to the machine for proper matching of speed.

Control Types

Standard variable-displacement models of piston pumps and motors for use in adjustable-speed hydraulic transmissions are available equipped for a variety of control methods. The basic control types, Fig. 8, are stem, handwheel, cylinder, servo and pressure compensator. The stem control is a straight push-pull type mechanism that can be actuated manually or automatically through a mechanical linkage, Fig. 9. The handwheel control is a purely manual device that permits control of displacement.

Cylinder control utilizes a hydraulic cylinder to control displacement. A solenoid-controlled directional valve is used to direct pilot pressure to displace the cylinder in one direction or the other, Fig. 10. This type of control permits two displacement positions and can be used with a fluid motor to provide low and high torque operation or with a pump to provide two different delivery rates. The servo control, a hydraulic boost mechanism, is a modification of the stem-control design. It is used with larger pumps and motors where the mass to be positioned is relatively large. An example of the application of a servo control is illustrated later (Fig. 15).

The pressure compensator control is a means of controlling torque in a fluid motor or delivery in a pump. The compensator responds to line pressure and adjusts the position of the yoke accordingly.

Applications

Speed of a fluid motor varies when the volume of oil delivered to the fluid motor is varied, when motor displacement is varied, or when both volume delivered and motor displacement are varied. These three basic combinations can be utilized to meet a wide variety of application requirements. An analysis of the power characteristics of the machine to be driven will generally determine the best combination for the job.

A transmission consisting of a variable-delivery pump combined with a constant-displacement fluid motor produces an adjustable-speed hydraulic transmission having virtually constant torque and variable-horsepower characteristics for a given load, Fig. 11. Pump delivery can be infinitely varied from zero to its maximum rated volume. The change in pump delivery is accomplished by displacing a yoke carrying the cylinder block assembly to alter its angular relation to the drive shaft. Piston stroke increases as the yoke moves off center, resulting in increased pump delivery. Since motor displacement is fixed, changes in pump delivery produce proportional changes in the speed at which the motor shaft rotates.

This variable-displacement pump, fixed-displacement motor transmission is suited to such constant torque applications as conveyor drives, machine tool feeds, stokers and processing machinery.

A constant-delivery pump, variable-displacement fluid motor combination produces a variable-torque, virtually constant-horsepower transmission, Fig. 12. Except for minor construction features, variable-displacement, piston-type motors used in this arrangement are identical with variable-displacement pumps. However, the motor operates at minimum speed and produces maximum torque when the yoke is at maximum angle. At minimum yoke angle, speed is maximum and torque minimum. Speed range of this type of piston motor is normally limited to 4 to 1. The range will be narrower if the minimum speed is greater than ¼ the maximum recommended, a recommendation which is based on optimum-life data.

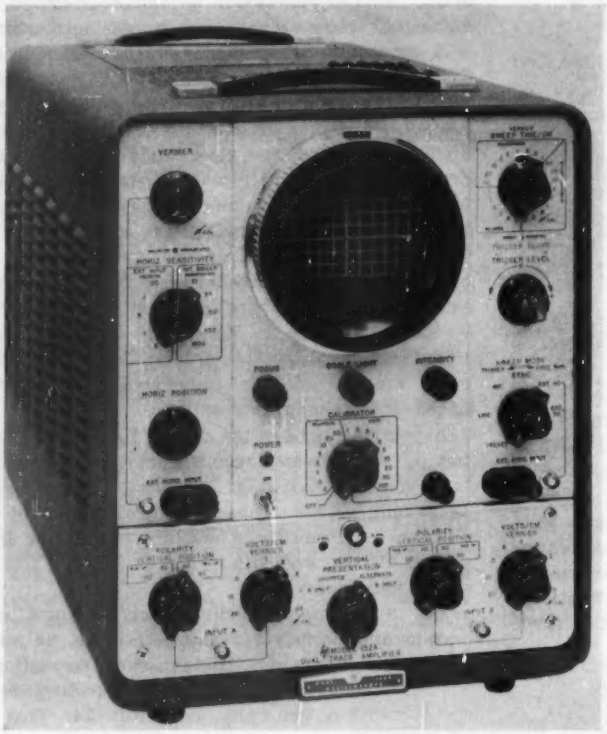
A common application of the fixed-displacement pump, variable-displacement motor transmission is a coiling drive, Fig. 13, designed for uniform tensioning. This transmission arrangement also fits the requirements of machine tool cutter drives, planer drives and other drives calling for constant horsepower.

For applications requiring any combination of torque and horsepower characteristics, an adjustable-speed hydraulic transmission consisting of a variable-delivery pump and variable-displacement fluid motor is generally used, Fig. 14. This type of transmission can be used to advantage in applications requiring a wide speed range, Fig. 15. Overall efficiency for this type of hydraulic transmission is approximately 85 per cent for all output speeds greater than 30 per cent of maximum.

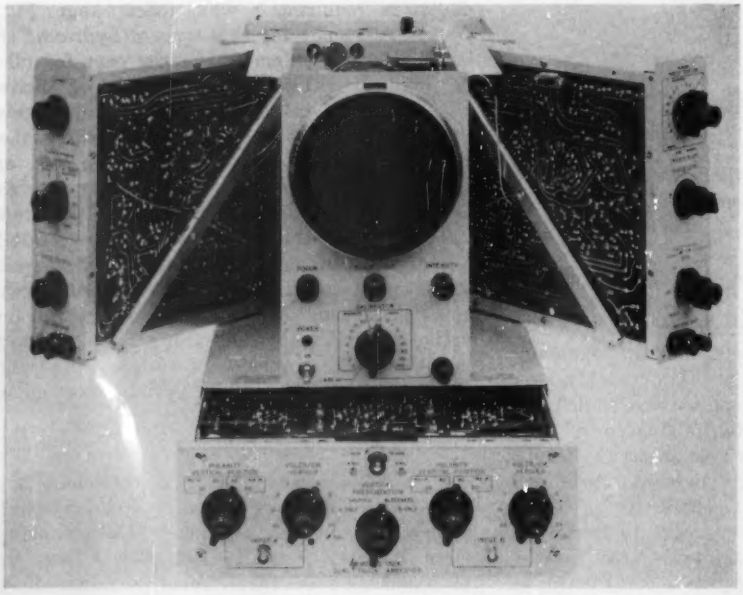
In development of variable-speed transmission circuits, the rules and factors governing the design of hydraulic circuits in general still apply. Only the basic considerations relating specifically to design of variable-speed hydraulic transmission circuits have been presented. Many possibilities and considerations other than those discussed and illustrated exist. The ability to easily create a special variation of one of the basic arrangements or combinations through proper selection and application of hydraulic valving is an inherent advantage of variable-speed hydraulic transmissions.

"The expansion of military electronics is a striking example of dependence on technological advances. Government purchases of electronic equipment in 1941 totaled $25,000,000. They totaled $2,300,000,000 in 1954—about a hundredfold increase in 13 years."—COLONEL O. G. HAYWOOD, *USAFR*.

Oscilloscope Designed for Accessibility



UNITIZED construction of a recently announced oscilloscope results in high accessibility for servicing and also makes it possible to remove and replace entire subassemblies. A product of Hewlett-Packard Co., the oscilloscope makes extensive use of etched circuits. Versatility of the instrument is also increased because a dual-channel vertical preamplifier may be quickly interchanged with a high-gain single-channel vertical preamplifier. An additional benefit of unitized construction is the functional grouping of controls.



Swing-out panels house the horizontal amplifier and the sweep and trigger circuits to provide a high order of accessibility. Interchangeable vertical amplifiers are constructed in the form of a drawer which slides in or out of the bottom of the 'scope. All connections are made by plugs. Many other circuits are also in unit form and are connected by plug-in type wiring. Spare subassemblies may thus be kept on hand and quickly installed in the event of a malfunction.

EXPLOSIONPROOF ELECTRICAL CONTROLS

- **Code Regulations**
- **Cost Factors**
- **Space Requirements**

By Victor Spagnuolo
Chief Engineer
Gemco Electric Co.
Detroit

Fig. 1—Multiple type explosionproof, electrical-control enclosure that replaces three standard explosionproof enclosures. Note ruggedness of the casing, number of bolts, and joint widths.

EXTREME care must be exercised in designing and applying electrical controls on machines that will be operated in hazardous atmospheres. To protect machines and personnel in these industrial locations, enclosures for electrical controls must be so constructed as to prevent flames from being emitted to the outside of the enclosure, Fig. 1.

When and when not to specify explosionproof controls is determined by a survey of the area in which the equipment or machine is to be installed or operated. Assurance of safety in hazardous locations is a three-way partnership affair among the *National Electrical Code* (*NEC*), Underwriter's Laboratory and the manufacturer of the equipment or controls. The *National Electrical Code* is compiled by the National Fire Protection Association. Underwriter's Laboratory is a nonprofit examination and testing service sponsored by the National Board of Fire Underwriters. *NEC* sets the minimum standards for reasonable safety and service of various types of fire protective electrical equipment. Basic *NEC* definitions of the four classes of hazardous locations are given in Table 1. *The responsibility of determining the existence and extent of the hazardous area rests with the local authority enforcing the code.*

Explosionproof equipment for use in the presence of combustible gases must be constructed so

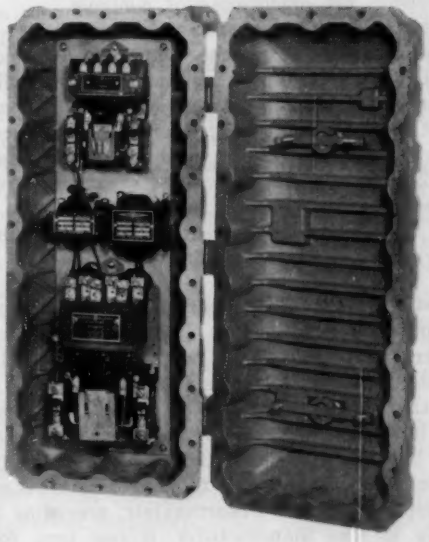


Table 1—Classes of Hazardous Locations as Defined by the National Electrical Code

Class I: Locations in which explosions or fire hazards may occur because of explosive or flammable gases in the air.

- Group A: Atmospheres containing acetylene.
- Group B: Atmospheres containing hydrogen or gases or vapors of equivalent hazards such as manufactured gas.
- Group C: Atmospheres containing ethyl ether vapors, ethylene, or cyclopropane.
- Group D: Atmospheres containing gasoline, petroleum, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors and natural gas.

Class I enclosures are constructed to withstand internal explosions and prevent escape of flame. The NEMA type 7 enclosure is designed for use in Class I, Group D areas.

Class II: Locations made hazardous by an atmosphere of combustible or conductive dust.

- Group E: Atmospheres containing metal dusts, including aluminum, magnesium, and their commercial alloys.
- Group F: Atmospheres containing carbon black, coal or coke dust.
- Group G: Atmospheres containing flour, starch, and grain dust.

Class II enclosures are constructed to exclude dust from hot or arcing parts and operate cool under a dust blanket. The NEMA type 9 enclosure is designed for use in Class II, Group E, F, G areas.

Class III: Locations in which it is impractical to prevent combustible dust from collecting on or in motors, lamps or other electrical devices in such quantities as to prevent normal radiation and cause overheating and combustion.

Class IV: Locations where easily ignitible fibers or materials producing combustible flyings are handled, manufactured, stored or used.

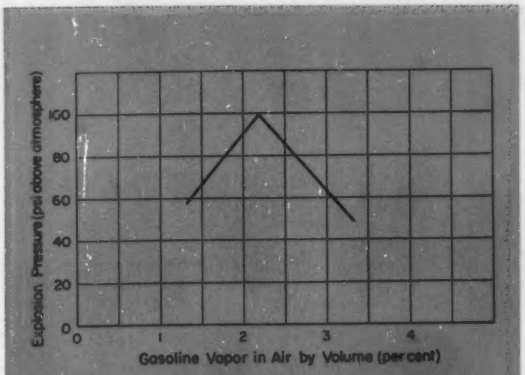


Fig. 2—Curve of explosion pressure developed by gasoline vapors in air.

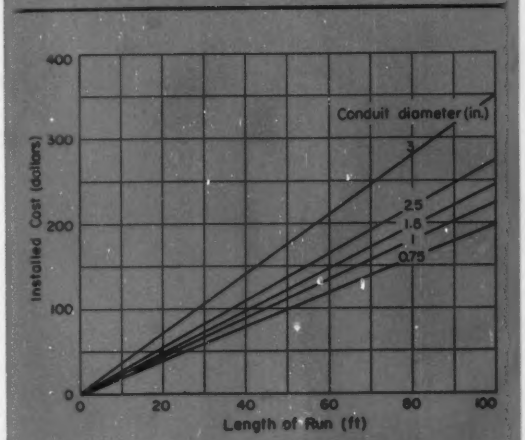


Fig. 3—Chart of average installed cost of conduit versus length of run.

that explosions within it will not cause a sufficient rupture to ignite surrounding gases or vapor-air mixtures. Joints must be of the metal-to-metal type with adequate width and small clearances to arrest flame propagation from the interior to the exterior. This construction is *not* vaportight. Under some conditions explosive vapors will penetrate, but the subsequent explosions will not ignite the exterior gases. Table 2 lists basic design requirements for explosionproof controls.

The problem of hazardous locations does not necessarily arise from the continual presence of volatile gas mixtures. The same dangers will be present if failure or leakage of other equipment might possibly emit a gas or fume that could cause an explosion. For example, as shown in Fig. 2, only a small percentage of gasoline vapor is required to produce intense combustion. In fact, a high vapor percentage actually reduces the chances of a man-killing explosion.

Cost Factors: When confronted with designing equipment for hazardous locations, there often appears to be one "easy out", i.e., mount all of the electrical controls in standard enclosures outside the hazardous area. This would be satisfactory if no controls were required at the installation, but this is seldom the case. Conduits from within the hazardous area to controls without must be properly sealed. Unfortunately, according to a survey by one manufacturer, it has been found

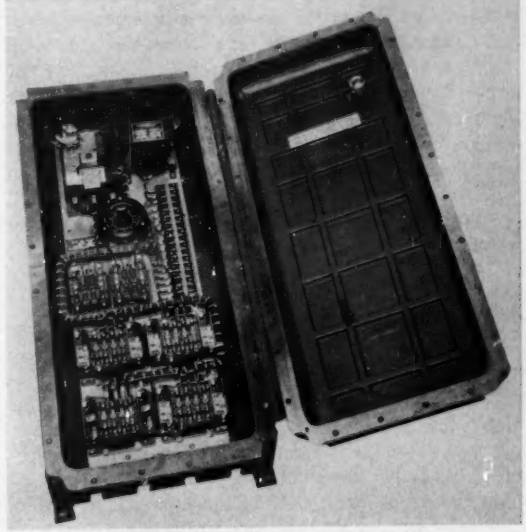


Fig. 4—Special, multiple type explosionproof enclosure that takes the place of eight separate enclosures.

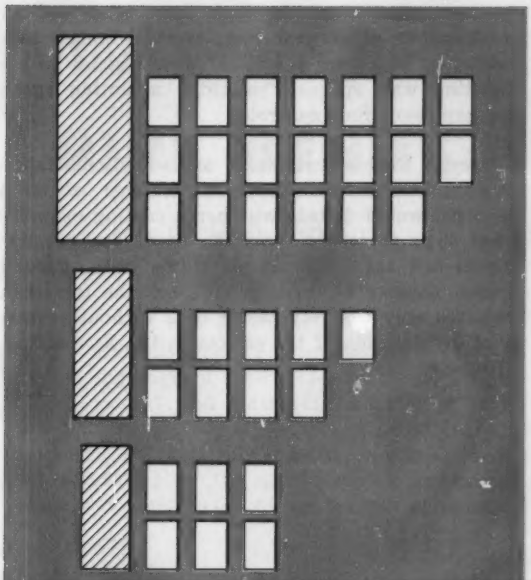


Fig. 5—Mounting-area demand chart for single explosionproof enclosures (white) and multiple explosionproof enclosures (shaded). Scale is 40 to 1. The three cases show the space required by a number of single standard enclosures and an equivalent-capacity special enclosure unit. Clearances between individual enclosures is for conduit and fittings.

Table 2—Design Requirements for Explosionproof Controls[1]

Major Features	Class I, Group D (Note 2)	Class II, Groups F & G (Note 3)
1. Casing or enclosures	Strength giving calculated safety factor of 4 over maximum explosion pressure. Control must also withstand hydrostatic test.	Substantial; dust-tight.
2. Bolt-strength spacing and location	A maximum spacing of 6 in. is best. Strength for safety factor of 4. Maximum hole clearance 0.031-in. with specified joint widths.	Sufficient number of bolts to maintain dust-tightness.
3. Joint widths and clearances	Threaded joint with 5 full threads suitable for all sizes. Flat joint must be 1 in. minimum path, 0.0033-in. maximum clearance.	Metal-to-metal joint, 3/16 in. minimum width. Gasket, ⅜-in. minimum width, permanently attached, permissible.
4. Sealing of leads	Leads tightly fitted and sealed with specified nonsoftening, noncracking compound, ⅝-in. to 1¼ in. depth according to size.	Same as Class I except reduced depth of 7/16-in. to ⅜-in. permitted.

1. Designs must always be proved by tests of representative samples. Constructions differing from details described in this table may be used if found by test to be equivalent. This table lists minimum requirements only.

2. Oil-immersed, Class I, Group D, minimum control requirements are (a) a substantial casing, (b) mechanical and soldered electric connections or joints as well as arcing parts immersed in oil to a minimum of 6 in., and (c) visible oil-level indicator.

3. Class II, Group E, equipment must meet other requirements in addition to those listed for Groups F and G.

Table 3—Cost Comparison of Starters*

Size	Standard NEMA Type 1	Explosionproof NEMA Type 7	Differential
1	$25.50	$83.50	$58.00
2	53.00	160.00	107.00
3	79.00	212.00	133.00
4	175.00	347.00	172.00

*Typical price differentials between standard and explosionproof starters based on average published list prices less 36 percent discount.

that only about 50 per cent of such seals have been properly maintained; the result is unsuspected hazards. There have been several accidents caused by improper seals. Fatalities usually result when an explosion occurs in manually operated nonexplosionproof control panels or circuit breakers. Thus, a thorough investigation must be made of maintenance procedures at a proposed installation before recommending a "solution."

Remote location of controls, however, is also a matter of economics. If it is merely necessary to run circuits through a nearby wall and find a nonhazardous location, then it is probable that the installation of nonexplosionproof controls will be cheaper. When controls must be removed a considerable distance from the hazardous area to find a safe location, the extra installation costs usually offset the cost difference between explosionproof controls and nonexplosionproof controls.

A sampling of electrical contractors, for instance, shows that the installed cost of a 1-inch conduit with conductors averages $2.25 per foot. This would nominally serve a size 2 motor starter. A NEMA type 7, size 2, explosionproof motor starter costs approximately $160. A NEMA size 2, type 1 nonexplosionproof motor starter costs $48. Thus, the price difference of $107 would be offset by a conduit run of 48 feet. If an outside type starter, NEMA type 4, which costs $100 were required, the difference would be only $47 and the breakeven conduit run would be only 16 feet. The data in Table 3 and Fig. 3 provide a quick check of the installation economics. In general, separation of the controls from the machine by more than about 30 feet is not economically practical unless ideal circuit-layout conditions exist.

Undoubtedly the most progressive wrinkle in solving explosionproof control problems has been the development of large cast-aluminum housings for multiple installation of starters, circuit breakers, timers, relays, etc. Such explosionproof enclosures have been made with inside dimensions up to 13½ by 46 by 7½ inches, having outside dimensions of 18½ by 50½ by 10½ inches. These enclosures are advantageous from two standpoints —original cost and space savings.

ORIGINAL COST: An explosionproof enclosure with 13½ by 46 by 7½ inches inside dimensions, for example, contains the same control components which would normally require 20 separate explosionproof enclosures, each housing one of the

components. Such a special enclosure costs approximately $1000, whereas the 20 separate enclosures will total approximately $2000. The latter figure does not include the costs of extra installation time, extra conduit, fittings, etc., which would be required to connect the separate explosionproof enclosures.

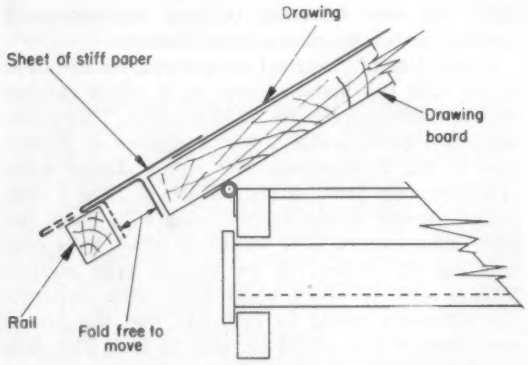
SPACE SAVINGS: When wall space or machine-mounting space is at a premium, the combination of electrical components in one explosionproof enclosure will reduce area mounting requirements by as much as 70 per cent. Typical multiple enclosures are shown in Figs. 1 and 4. For the purpose of estimating space requirements, refer to the area demand chart, Fig. 5. This chart naturally does not meet all needs, since there is an endless combination of control components commercially available. However, it will serve as a guide in estimating wall space or machine mounting space for explosionproof controls.

Special Enclosures: These are sometimes fabricated of steel weldments. The number of units required would dictate whether a casting or weldment type enclosure would be used. The requirements are the same as to flame path, ground joints, number of threads, etc., but the test then requires only a safety factor of 2 without permanent deformation of the enclosure, i.e., 2 × 135 = 270-pound test.

Tips and Techniques

Protecting Drawing Edges

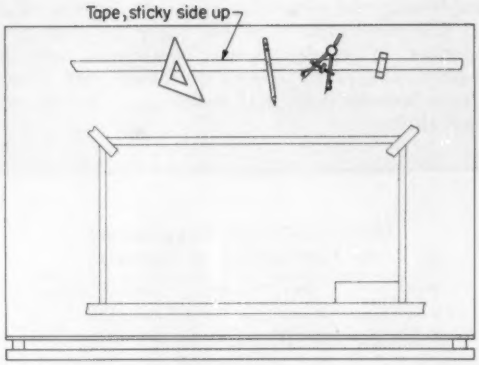
Protecting the edge of a drawing from fraying is a common problem. One simple way to do this is to fold a sheet of fairly heavy paper such as



an old blueprint as shown, and insert it between a rail along the edge of the board and the board. A portion of this paper will then cover the edge of the drawing. Because the protective paper is not taped or otherwise fastened, it does not interfere with any required movement of the drawing.—EWALD SCHLACHTER, *draftsman, Kiekhaefer Aeromarine Motors, Oshkosh, Wis.*

Keeping Tools on the Table

A simple and easy method for keeping triangles and other drafting tools on the table even when the table is inclined at angles as high as 45 degrees is provided by masking tape. Simply place a length of 1 in., or wider, tape along the upper edge of the board, with the sticky side up. Fasten it at ends and the middle with short pieces applied



in conventional fashion. Tools placed upon the tape will not slide and may be picked up as easily as from any other surface when they are needed.—G. L. STANTON, *layout draftsman, Mast Development Co., Davenport, Iowa.*

Drawing Board Surface

Drawing boards are often covered with paper to provide a smooth drawing surface. This paper may stretch and wrinkle with humidity changes and is also susceptible to damage and tearing. A superior surface is provided by battleship linoleum which is smooth, resilient and easy to keep clean. The linoleum may be purchased to size and cemented to the board. For eye ease, dark-green is suggested. This also eliminates troubles with doodlers. W. R. EDGER, *draftsman, Outboard Marine Corp. of Canada Ltd., Peterborough, Can.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Nomograph for

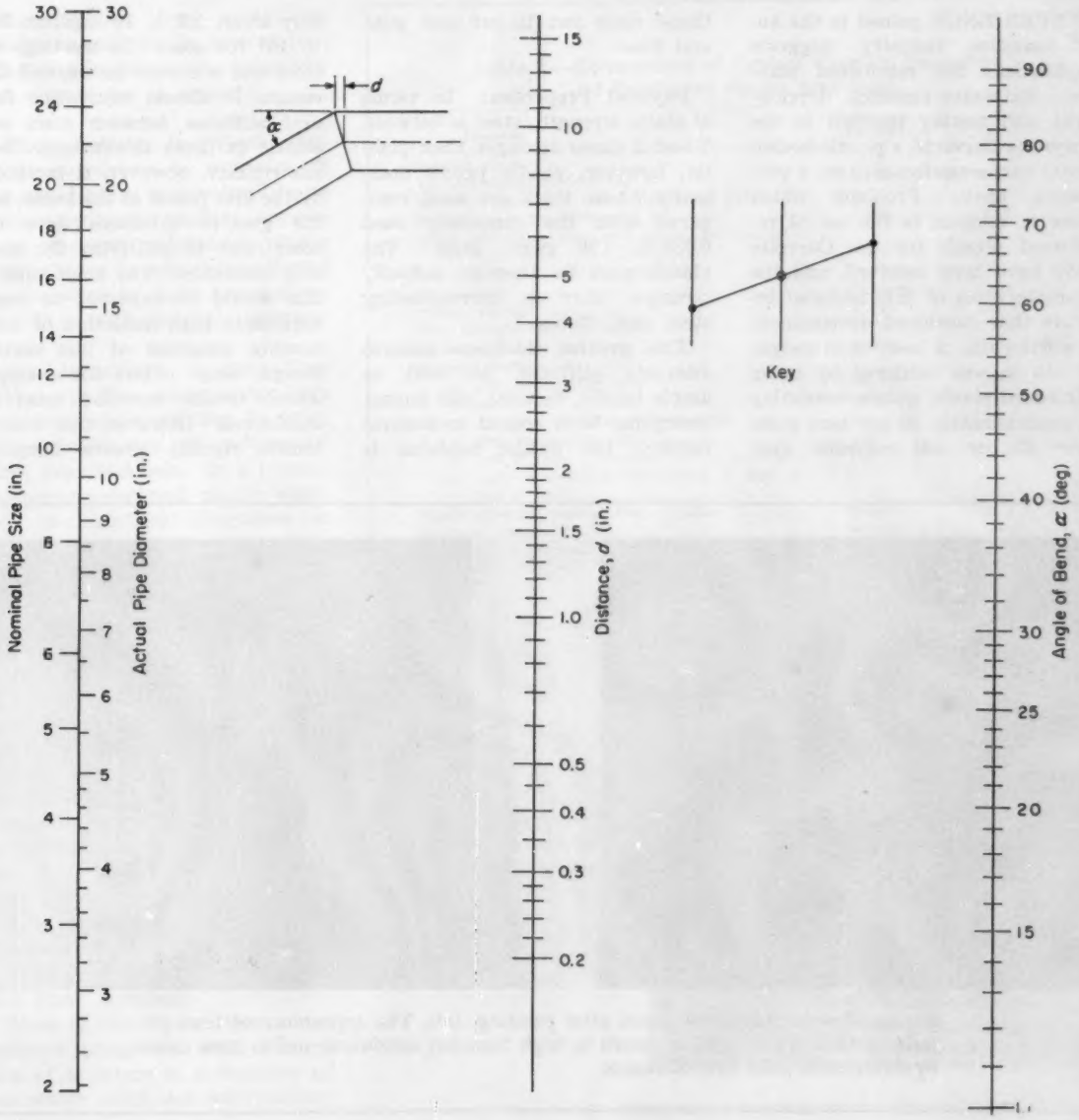
PIPE BENDS

MACHINE DESIGN
Data Sheet

By D. S. Davis
Professor of Engineering
University of Alabama
University, Ala.

WELDED pipe bends can be laid out by noting angle of bend α (see sketch with nomograph) and measuring distance d, which is equal to the actual outer radius of the pipe times tan $\alpha/2$. But this equation is solved readily and accurately by the accompanying nomograph, which was constructed by application of standard methods.* For welded and seamless steel pipe the nominal pipe-size scale is used; actual outside diameter is shown on the right-hand side of the same scale. As an example, joining the points with a straightedge shows that the distance d for nominal 8-inch pipe and an angle of bend of 60 degrees should be 2.5 inches.

*D. S. Davis—*Nomography and Empirical Equations*, Reinhold Publishing Corp., New York, 1955, Chapter 6.



Pipe Bends

Design factors for

Reinforced Plastic Panels

By John G. Coffin
Chevrolet Motor Div.
General Motors Corp.
Detroit

EXPERIENCE gained in the automotive industry suggests applications for reinforced plastics. Extensive research, development and testing resulted in the Chevrolet Corvette, a plastic-bodied sports car, manufactured on a production basis. Problems which arose in relation to the use of reinforced plastic for the Corvette body have been resolved, and the characteristics of this material indicate that continued development is worthwhile. A body-shell weight of 340 lb was achieved by using reinforced plastic panels consisting of approximately 40 per cent glass fiber, 45 per cent polyester synthetic resin and 15 per cent mineral filler.

Physical Properties: In terms of static strength, steel is between 2 and 3 times stronger than plastic; however, plastic panels nominally 0.1-in. thick are used compared with the commonly used 0.036-in. (20 gage) steel. The plastic part is, thereby, actually stronger than a corresponding steel part, Table 1.

This greater thickness assures adequate stiffness, as well as ample tensile, flexural, and impact strengths. With regard to flexural rigidity, the plastic modulus is only about 1.3×10^6 against 30.0×10^6 for steel. In bending, the thickness is a cube factor, and this results in almost equivalent flexural stiffness between steel and plastic in these thicknesses. Tensile rigidity, however, is increased by the first power of thickness, and the greater thickness does not come close to nullifying the modulus deficiency. The magnitude of this would be expected to cause noticeably high deflection of load-bearing members of box section design, hinge pillars for example, where tensile modulus must be considered. However, this lack of tensile rigidity proves harmless

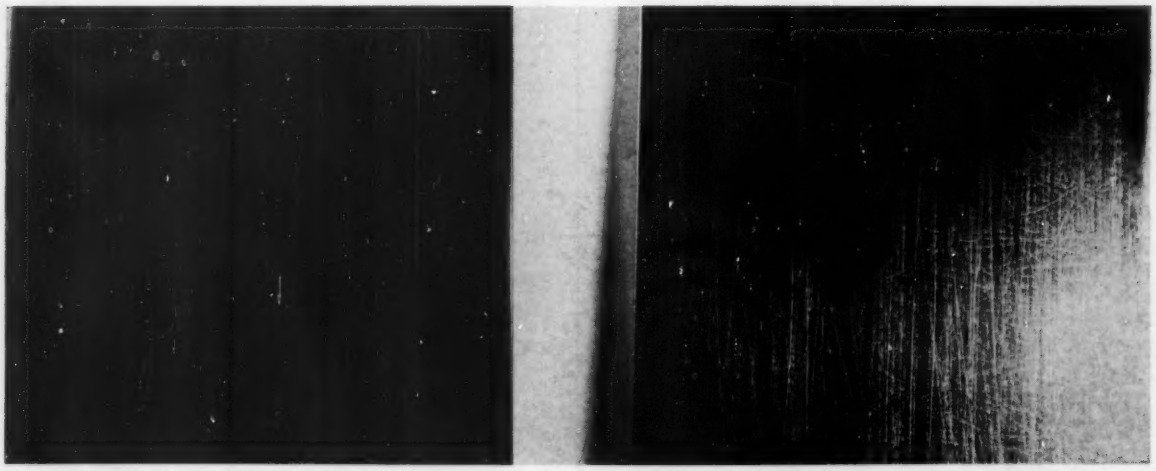


Fig. 1—Reinforced plastic panel after painting, left. The appearance of fiber pattern, or fiber trace, right, is caused by high humidity conditions and to some extent by differential paint film thickness.

Successful application of plastic panels has been demonstrated by Chevrolet Corvette.

under dynamic load application conditions and can be ignored provided the larger static deflections are allowed for in assembly.

Fiber Pattern in Weathering: While impervious to corrosion in the usual sense in practically any environment, the surface appearance of some reinforced plastic compositions is adversely affected by exposure to high atmospheric humidity and elevated temperatures.

The appearance of glass fiber pattern, or fiber trace, under high humidity conditions, Fig. 1, right, is partially due to differential paint film thickness. In a typical, unpainted reinforced plastic molding, the surface roughness is caused by resin shrinkage, and the fibers are in relief over hollows in the resin-rich "matrix." After painting, this roughness is obscured as the paint fills in the depressions, Fig. 1, left. On subsequent exposure to moisture, however, the paint film absorbs water and swells in proportion to its original thickness. Consequently, the greater thickness of paint over resin-rich areas becomes raised above that covering the fibers, and the "fiber map" becomes noticeable. Actually, then, this fiber pattern is visible in reverse; that is, the surface over the glass fibers is depressed and that over resin-rich areas is raised.

Some of the fiber pattern which becomes prominent with absorption of moisture is a function of the water resistance and polarity

Table 1—Comparison of Typical Physical Properties of Reinforced Plastic and Steel

Property	Reinforced Plastic	Steel (AISI C-1010)
Specific gravity	1.50	7.87
Thermal expansion (per deg F)	12×10^{-6}	6×10^{-6}
Thermal conductivity (Btu/hr/sq ft/deg F/in.)	2	310
Specific heat (Btu/lb/deg F)	0.3	0.1
Water absorption (per cent weight increase after 24 hr)	0.5	.....
Corrosion (5 per cent salt spray)	none	rusts
Flammability	burns slowly	.....
Tensile strength (psi)	17,000	45,000
Yield strength (psi)	17,000	35,000
Flexural strength (psi)	25,000	.....
Flexural modulus		
at room temperature (psi)	1,300,000	30,000,000
at 180 F (psi)	600,000	30,000,000
Impact cracking resistance (dropping ball test)		
at room temperature (in.)	10	6
at −10 F (in.)	6	6
at room temperature after aging 7 days at 212 F (in.)	8	.....
Impact strength, notched Izod (ft-lb/in.)	15 to 20	.....
Hardness (Rockwell)	M-100	B-80
Wet strength retention (per cent original strength retained after 2 hr in boiling water)	70	.....

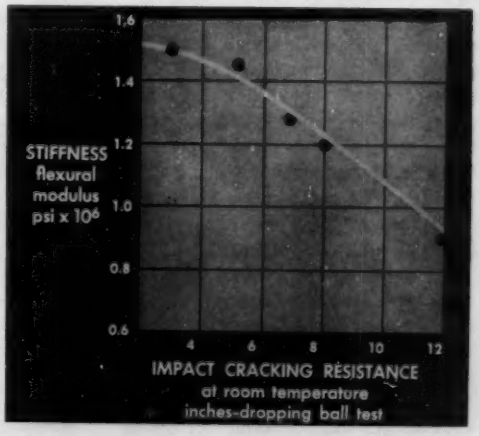


Fig. 2 — Relationship between stiffness and impact cracking resistance of reinforced polyester resin.

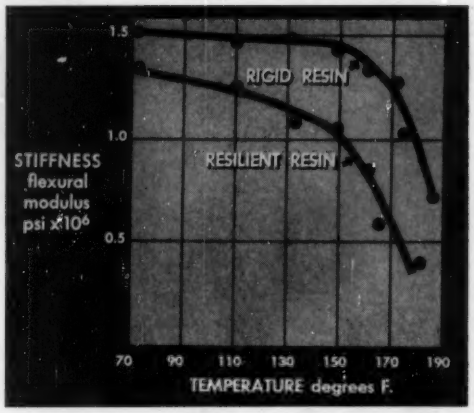
of the resin used in making the plastic panels. To keep the influence of the resin on fiber pattern at a minimum, 0.5 per cent maximum water absorption after 24-hr immersion of uncoated plastic parts in water at room temperature is specified.

The appearance of fiber pattern due to exposure to elevated temperature may be permanent or temporary. If the resin in a laminate is undercured, permanent shrinkage occurs on heating. The resultant fiber pattern can be removed by polishing the overlaying paint film. Fiber pattern caused by undercuring can be averted through proper curing and hardness control by the plastic molder. Tests of strength and modulus also will evidence improperly cured resin. Temporary fiber appearance can be noticed on heating of fully cured, painted panels to about 180 F or higher. These temperatures cause the glass-rich and resin-rich portions to expand differentially. When the material cools, the pattern disappears. Fiber pattern attributable to this phenomenon is, therefore, of little practical concern.

Resilience and Rigidity: Originally, it was found that reinforced polyester laminates having a resin-rich surface (gel-coat) of poor flexibility (low cured elongation) were susceptible to cracking if used for automobile body panels subject to localized impact loads or high and repeated flexing stresses. For example, stones thrown by the car's tires would cause "stone bruising," or star-like cracks, on the outer surfaces of panels which were impacted on the underside. A reverse impact, or falling ball impact, test was developed to evaluate resistance to this type of damage. Early experimental bodies having rigid resin gel-coats developed numerous failures of this type in service on gravel roads.

As service background was accumulated it was found that die-molded, reinforced plastic panels without gel-coat have superior resistance to impact and flex cracking in service in comparison with similar gel-coated, hand lay-up or bag-molded panels of equivalent impact cracking resistance. The latest data on this subject, however, point to the fact that the fatigue life of a reinforced plastic laminate is influenced by resin elongation. Laminates made with more flexible resins have longer fatigue life with respect to cracking than do those incorporating more brittle resins.

Fig. 3—Effect of temperature on stiffness of reinforced polyester resin.



Fatigue tests have been run under constant load and constant deflection conditions at stress approximating 20 per cent of the ultimate flexural strength of the most rigid panels. It was found that endurance limit is not entirely proportional to strength but that the additional factor of resilience enters the picture. A point of interest is that polyester resins which give good impact resistance and higher endurance limits tend to absorb more water than do the more rigid resins. The qualities of impact resistance and low water absorption are fundamentally contravening, yet desirable, characteristics of a resin, just as are the broader characteristics of rigidity and resilience.

As would be expected, tensile rigidity must be compromised for the sake of impact resistance, Fig. 2. Material made with resin that is very rigid and has a flexural modulus of 1.5 million psi at room temperature will have falling-ball impact resistance of only 6 in. That is, at a height greater than 6 in. a ½-lb, 1½-in. diameter ball dropped on a 0.1-in. thick panel supported in a 5-in. diameter frame may cause cracking. If more resilient resin is used which will permit a laminate to pass the reverse impact test at 12 in., the modulus will drop to about 1.2 million psi.

Stiffness of reinforced polyester is decreased with increasing temperature, Fig. 3. A typical composition made with rigid resin will suffer a modulus drop from about 1.6 million psi at 72 F to 800,000 psi at 180 F. One incorporating a resilient resin to enable it to meet a 12-in. reverse impact requirement will decrease from 1.3 million psi to 500,000 psi. At temperatures between room temperature and 180 F, the more resilient material will be at an even greater disadvantage. However, because reinforced plastic has superior ability to damp out and shorten the duration of vibration periods, no objectionable degree of flexibility of a resilient, reinforced polyester body has been observed.

Just as the modulus of reinforced polyester is decreased with higher temperatures, low temperatures will cause the material to become brittle, thereby offering less impact resistance, Fig. 4. Accordingly, sufficient impact resistance is specified to insure adequacy at any temperature likely to be encountered in service.

Bonded Joints: Some of the most difficult problems experienced in working with plastic panels have been basically ascribable to bonding practices and bonded joint

BEARING TIPS by McGill

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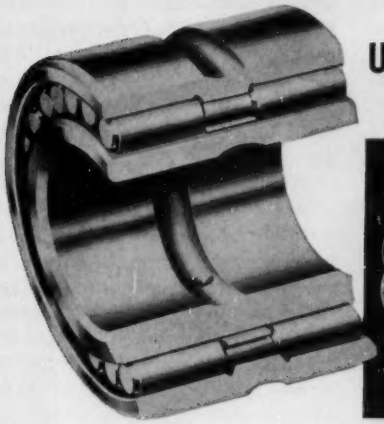

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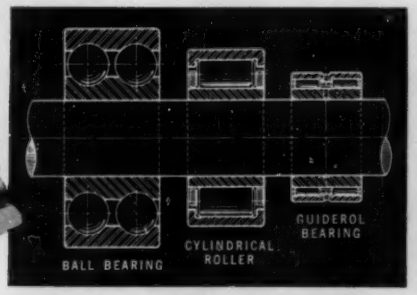

Showing graphically how a McGill GUIDEROL precision needle bearing permits more streamlined designing by supporting comparative loads in significantly smaller radial space than other types of bearings. Bulky and more costly housing space is easily avoided.

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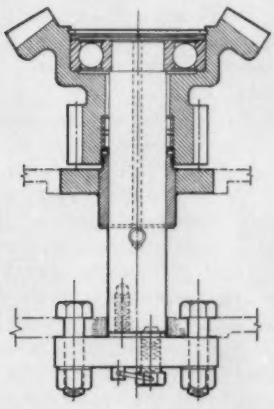
GUIDEROL® *bearing capacity, space economy proved in power shovel vertical reversing shaft assembly*

Baldwin - Lima - Hamilton Corp. uses a McGill GUIDEROL bearing, on ½ cubic yard power



shovels, to carry spur pinion loads in the vertical reversing shaft. The high capacity of the bearing in small radial space is an important factor in selection of this bearing. Only 3.75" in diameter, it has a load capacity of 28,560 lbs. at 100 rpm. In the power shovel application, it supports 14,150 lbs. at 76.3 rpm, which gives a high margin of safety. The center guided rollers also are especially adaptable to a vertical application such as this.

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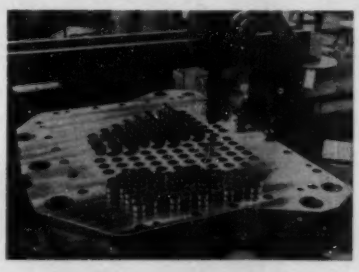

Multiple spindle drill heads require support of spindles on very close centers

Crowding a great number of drill spindles into a small area, Zagar, Inc., of Cleveland has found the McGill GUIDEROL bearing construction especially suited to the needs of multiple drill head units. The full bearing width rollers provide rigidity and more than adequate load capacity and in a bearing only 1.25" in bore diameter.

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design. Surface waviness found on exterior parts where a flange is bonded to the inside surface of an outer panel has been particularly disconcerting. Variations in the fit between the two surfaces result in varying bond line thickness and corresponding differences in the amount of resin shrinkage. The effect is a rippled appearance on the exterior, highly finished surface where the shrinkage of the polyester-base bond material pulls the outer panel into the flange in varying amounts. Even though this rippling may be only 0.001-in. in height or depth, it is apt to be noticeable due to the high-gloss finish of the body, especially in highlighted areas. Even the use of epoxide resins having very low shrinkage characteristics will not eliminate this completely if the bonded surfaces match poorly. The solution is, of course, to control dimensional accuracy of mating bonded parts closely and to remove any excess bonding material which is squeezed out of the joint. With the application of these bonding practices, this problem has been surmounted to a considerable degree.

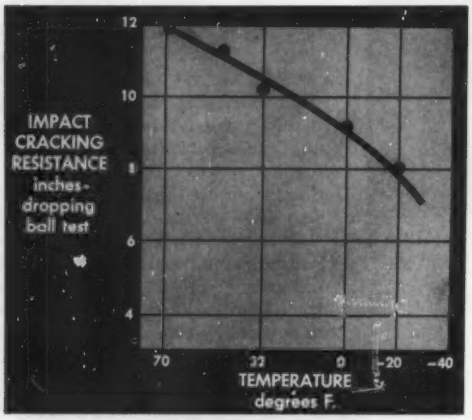


Fig. 4—Effect of temperature on impact cracking resistance of reinforced polyester resin.

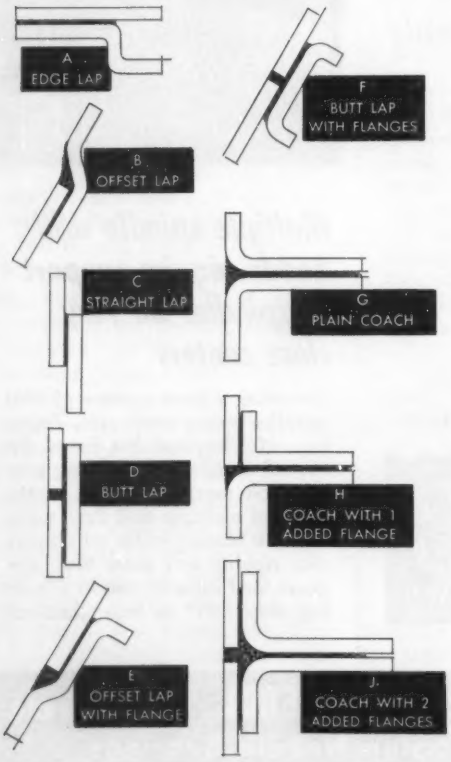
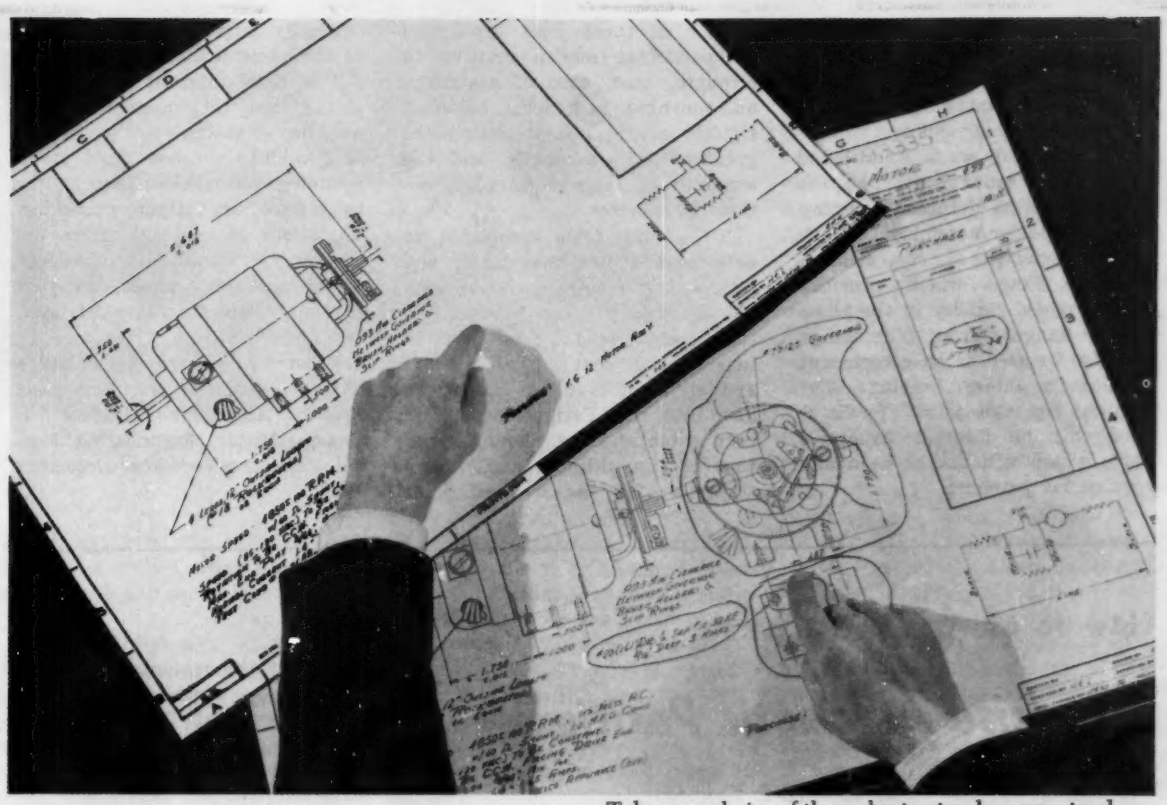

A EDGE LAP
B OFFSET LAP
C STRAIGHT LAP
D BUTT LAP
E OFFSET LAP WITH FLANGE
F BUTT LAP WITH FLANGES
G PLAIN COACH
H COACH WITH 1 ADDED FLANGE
J COACH WITH 2 ADDED FLANGES

Fig. 5—Typical joints used in bonding reinforced plastic panels together.

Patching over exterior joints presents other problems related to resin shrinkage. If the patch area is large, the volume decrease on curing is correspondingly large. The mass effect, meanwhile, creates high exothermic heat, making the patch tend to expand. If the internal residual stresses in these patches were high enough, the material would crack immediately. In this case it would be patched again, but there is a slight possibility that some internally stressed but apparently good joints might develop cracks in service after comparatively few light load applications. To cope with this problem, Chevrolet uses low exotherm resins exclusively, which are filled with materials to absorb some of the heat generated on curing and to reduce the gross shrinkage. This problem can be alleviated further by reducing the volume of the patch over troublesome joints. Patch size is held to a minimum by improving dimensional accuracy and by redesigning to decrease the gaps between mating parts.

These early problems precipitated an extensive study of joint design for reinforced plastic panels. A program of making and testing joints of various types, Fig. 5, was undertaken to avert any bond fatigue failures. The edge lap joint and plain coach joint, Fig. 5*a* and *g*, respectively, have handling advantages in assembly operation and are the least expensive of the types investigated. The coach joints, Fig. 5*g*, *h* and *i*, provide a natural locating surface, and the finishing required is minimized. Tests of both static and fatigue strength properties have established that reinforced butt joints, Fig. 5*d* and *f*, are superior to even reinforced coach joints under loads simulating ac-



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tual service conditions. Accordingly, butt joints are specified wherever feasible.

The offset lap joints, Fig. 5*b* and *c*, have the advantage, like the coach joints, of naturally locating large panels for assembly. An offset lap variation, Fig. 5*e*, incorporates a flange which provides greatly added rigidity in the plane of the flange width. The flange can also be used as an attachment surface for lateral bracing. The straight lap style joint, Fig. 5*c*, is used only on interior structural parts which will not be seen and require no patching.

Each of these joint types has its particular merits relative to strength, cost, ease of assembly, and finishing. In general, balanced rigidity across a joint contributes greatly to its strength, and the strength of more rigid constructions is superior.

All of the tests completed to date have shown that static and fatigue test results correlate with one another for the bonded sections investigated. Tests both in tension and flexure under static and dynamic loading conditions have been run. Fatigue loads have been established at about 20 per cent of the ultimate static bond strength (for the weakest joint statically) and the joints compared at the same load.

Test data obtained thus far indicate that the relative bonding qualities of resins greatly differing in flexibility do not show corresponding differences either in load to failure or fatigue properties. Variations in residual stress due to curing conditions, however, would materially affect any comparison between two or more bonding materials.

From "Engineers Set Serviceability Standards for Reinforced Plastic Automobile Bodies" in General Motors Engineering Journal, *October-November-December,* 1956.

How to use punched tape for

Precise Automatic Positioning

By Edward E. Kirkham

Project Engineer
Pratt & Whitney Co. Inc.
West Hartford, Conn.

THE words "numerical control" in connection with any machine tool imply that the machine tool can provide the necessary coordinate axes from which all measurements will be taken. These axes must bear a known mathematical relationship to each other. For example, if the machine has rectangular co-ordinates with three axes these axes must be straight and mutually perpendicular. Any deviation from this requirement will result in a corresponding error in all parts produced on that machine using numerical control.

It is also necessary in a numerically controlled machine that a measuring system of suitable accuracy be provided. This measuring system should be one whose output can be used to control the movement of the machine.

Tape: The first requirement of the control system is a suitable method of handling and storing the digital data. In conventional card handling equipment, once the deck has been used, the operator must move it by hand from the stacker back to the feed hopper. A suitable card feed mechanism must necessarily be extremely accurate and smooth so exactly one card will be handled at a time without damage. On the other hand, the mechanism for handling punched tape without damage to it can be much simpler than that necessary for handling cards; also, the tape may be automatically rewound. For some applications the paper may not be sufficiently rugged for repeated handling and a plastic tape may be substituted. To make use of paper as well as plastic tapes, density of information on the tape should be low so that variations in tape size or position will not result in reading errors. For that reason, a tape wider than that usually used in office equipment may be chosen.

Tape Reader: There are two distinct means of reading the information from a punched record. One of these is the dynamic method in which a small group of holes is sensed at one instant and the information so read is stored. The tape is run until this buffer storage unit accumulates a sufficient number of digits for the machine to accomplish one operation.

The static reading method, on the other hand, eliminates the need for buffer storage. The punched record is already a storage medium, and the greatest reliability will be obtained when the storage capability of the tape is used. The tape is moved into position and stopped; then all the data necessary for a single operation are read at one time and that data presented to the machine continuously. When the machine operation has been completed and checked, the tape can then be advanced one field or block so that new information may be presented.

One tape reader design uses a pneumatic sensing system, Fig. 1. Air is forced through holes in the tape to an enlarged chamber with a neoprene diaphragm providing sufficient force to operate a reliable industrial control limit switch.

Tape Punch: Accurate longitudinal spacing can be provided by a tape punch having a moving carriage similar to that used in an ordinary typewriter, Fig. 2, so that the tape can be clamped just before the block signal hole is punched and then the numerical

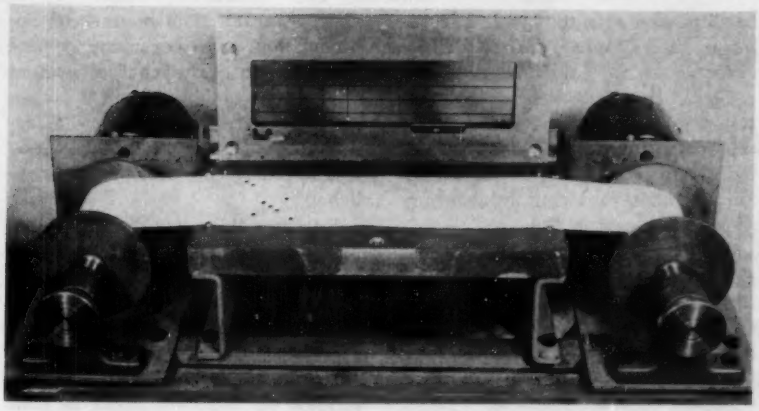


Fig. 1—Tape reader using a pneumatic sensing system.

data inserted in the tape as the carriage is spaced along accurately by a rack and escapement.

Measuring System: Many systems of measurement were studied at Pratt & Whitney in an effort to find one which was especially suitable for this precise positioning system applied to a jig boring machine, Fig. 3. The machine tool requires a total movement along one axis of 60 in., and it is necessary to be able to set that slide to an accuracy of 0.0001-in. If a single digital-to-analog converter were to be used, it would require an accuracy of one part in 600,000. It was decided that a more practical approach would be to break the problem up into several lower accuracy digital-to-analog converters with proper bench marks for refining the accuracy as the successive settings are made.

This philosophy fits well with the measuring system which had been used for a number of years on manually operated jig borers. This system uses a measuring bar having accurately located magnetic lugs at 1-in. intervals combined with a micrometer screw for adding distances less than 1 in. The magnetic center lines of these lugs can be sensed by an inductance bridge circuit with the sensing head so positioned that the lugs move by it without any mechanical contact. It is possible to calibrate this measuring bar by stoning the sides of each lug independently. The accuracy is not limited by the manufacturing technique; rather the accuracy of a given bar can be improved until no measurable errors remain. It is then only necessary to provide a helical potentiometer geared to the drive screw to position the slide to the nearest inch in 60 in. Then the sensing head can locate the next 1-in. lug on the measuring bar, and an extremely accurate setting can then be made at 1-in. intervals using a digital-to-analog converter of commercial accuracy.

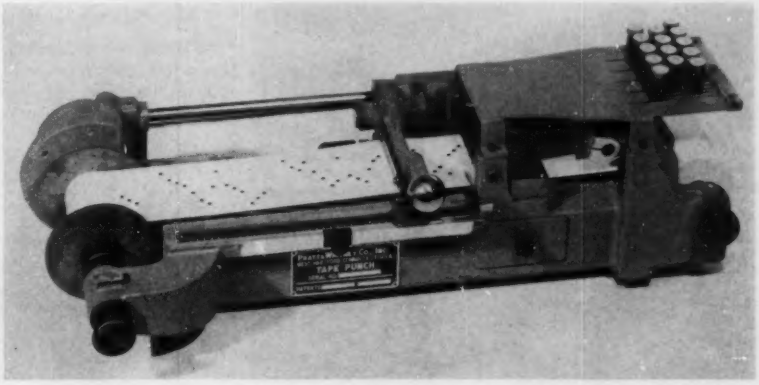
The arrangement of components involved in this numerical control system is indicated in Fig. 4.

To provide additional stopping points between lugs on the measuring bar, the sensing head is moved a maximum distance of 1 in. by an extremely accurate instrument screw. It should be clearly understood that this screw does not move the slide itself, but only the sensing head. This micrometer screw has been used in the conventional machine for a number of years and its reliability is proved. Anyone who has manufactured such instrument screws is familiar with the difficulty of providing a screw of accurate lead and satisfactory linearity at the same time. Lapping the nut to the screw can provide linearity but will usually produce some error in lead. Pratt & Whitney has provided means, however, for compensating for lead errors in the electric control system and has made the screw uniform in lead to an accuracy of one part in 50,000.

Digital - to - Analog Converters: As soon as the automatic or manual switch calls for a new position, the tape is advanced to the next block signal hole. The tape stops and the pneumatic switches are operated corresponding to the punched holes. The switches for the first two digits before the decimal point connect to appropriate taps on an autotransformer to produce an analog voltage of magnitude proportional to these digits. The autotransformer has a distinct advantage over the usual two-winding type in that undesired phase shifts, caused by leakage reactance in one portion of the winding, are offset by identical effects in the other portion. If phase shift is permitted, an imperfect null will result at the balance point.

The tape is checked for double punch and blank column for each digit read. Closure of more than one contact for a given digit will

Fig. 2—Tape punch with moving carriage which provides accurate longitudinal spacing.



result in a short circuit on the digit transformer which will trip a magnetic overload relay. Failure to operate at least one switch will also cause a short circuit. These short-circuit currents are limited by a series resistor.

This analog voltage is fed to a discriminator which compares it to the voltage fed back from a helical potentiometer geared to the table drive screw. The output of this discriminator is used to operate the multispeed gear box to position the table approximately.

The two digits immediately following the decimal point are fed into the micrometer screw drive to obtain its approximate position. This approximate position is made exact by means of an additional bench-mark system. These bench marks are at 0.0100-in. intervals.

Similarly, the third and fourth digits following the decimal point are fed into still another digital-to-analog converter which provides a signal that is compared with a feedback potentiometer for setting the screw at positions between bench marks.

Drive Control: After the table has come to its approximate position and the sensing head has been moved to its exact position by the micrometer drive, the table is advanced at a very low speed until the sensing head indicates correspondence between the measuring bar lug and sensing head. The table is then stopped and the screw reversed to release tension.

Thus, the slide has been positioned to the required accuracy of one part in 600,000 using three individual digital-to-analog converters, each requiring an accuracy of only one part in 100.

The direction and velocity of final approach is extremely important in making a precise slide setting. Since there is need for being certain that approach direction and velocity are always the same, an ordinary servomechanism cannot be used for positioning a slide to high accuracy. The manner of approach has been permanently programmed into the control system so that the machine always makes its final setting in the same direction and at a series of velocities which have been previously established.

Rotary tables can be controlled precisely using an analogous positioning system applied to a circular slide, Fig. 5.

From a paper entitled "Precise Positioning with Numerical Control" presented at the AIEE Conference on Machine Tools in Cincinnati, October, 1956.

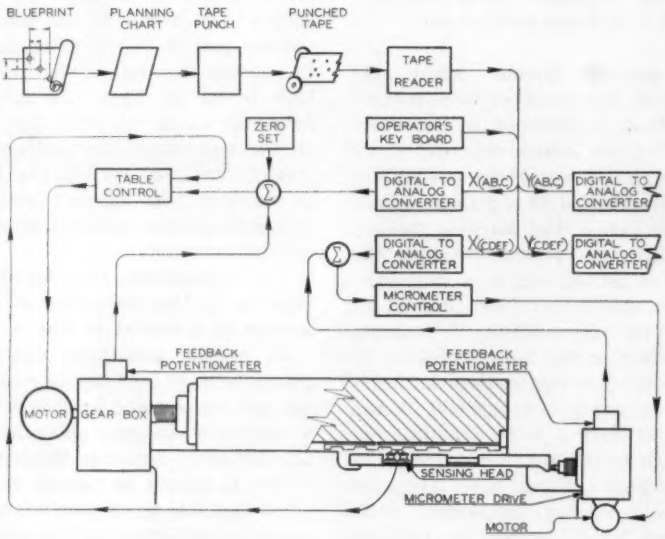


Fig. 4—Schematic of punched tape control system for automatic positioning.

Fig. 3—Vertical spindle jig boring machine equipped for punched-tape positioning.

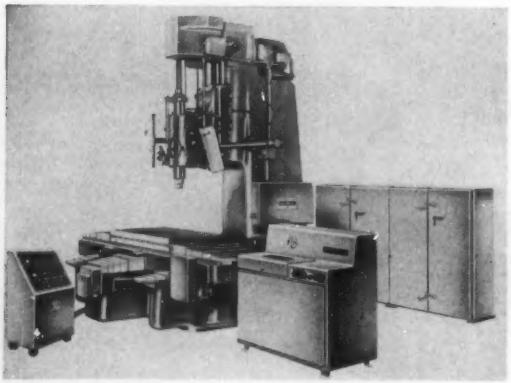
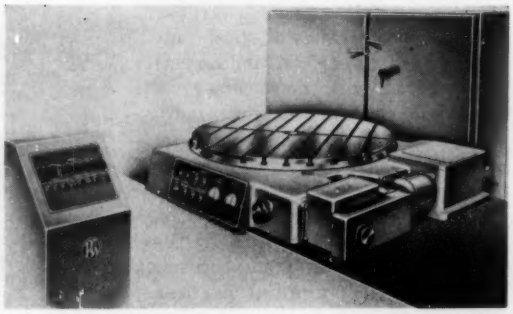


Fig. 5 — Rotary table equipped for positioning with numerical control.



"SWITCH!" said Ostuco

. . . and savings were surprising!

Pleasant surprise, too! Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc. Lancaster, Pa., was machining OSTUCO seamless tubing to make a clutch release bearing collar used as original and replacement equipment. Results were fine!

Then word came from OSTUCO, recommending a switch to OSTUCO's newly developed NP-60, tubing specially processed for machineability. Cost was slightly higher, but BCA and OSTUCO engineers predicted the savings would justify the change.

they switched . . .

and they SAVED!

	Regular	Specially Processed NP-60
Production per 8 hour shift (units)	675	840
Production time per 1000 units (hours) . . .	12.35	10.03
Total Labor per 1000 units (man-hours) . .	13.09	10.63

Besides the savings, Bearings Company of America was pleased with the better finish of the new part. They point out that the collar in photo above "shows the finish as it comes directly off the machine."

It happens this way often enough to warrant checking with OSTUCO about your tubing applications and production problems. Contact your nearest OSTUCO Sales Engineer or write direct to the Shelby factory —there's no obligation!

OSTUCO SHELBY, OHIO

OSTUCO TUBING

SEAMLESS AND ELECTRIC RESISTANCE

WELDED STEEL TUBING—Fabricating and Forging

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HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Polyester Film Adhesives

Modified synthetic rubber and vinyl types of adhesives for Mylar polyester film and a new class of polyester adhesives for same use are described in bulletin. They have high specific adhesion, good clarity and color stability, and low color and odor. Application data are included. 8 pages. E. I. du Pont de Nemours & Co.

Circle 581 on page 19

Valves

Illustrated brochure S-2021 R describes line of precision valves and presents technical information. Circle Seal Products Co.

Circle 582 on page 19

Case Conveyor Chain

Capable of flexing in two directions, 9250 case conveyor chain described in bulletin 56-73 is for handling cartons, cases, crates and cans. It flexes laterally to a radius of as little as 12 in., has a broad, flat carrying surface and will fit standard 2-in. cracks. 4 pages. Chain Belt Co.

Circle 583 on page 19

Terminal Blocks & Kits

Selector chart on terminal blocks and terminal block kits found in condensed catalog 556 quickly shows the best block for each application. Technical descriptions, specifications and prices are included for a variety of terminal types. 8 pages. Curtis Development & Mfg. Co.

Circle 584 on page 19

Thermocouples

Construction and application of thermocouples and radiation detectors used on industrial control applications are discussed in illustrated bulletin F-5228-3. How to check, make and select thermocouples is related. 40 pages. Barber-Colman Co., Wheelco Instruments Div.

Circle 585 on page 19

Strain Gages

Flat grid, fine pitch Bakelite SR-4 strain gages, said to be superior replacements for small sizes of wrap-around gages, are among new products described in supplemental price list. Other new products are self-compensated gages, high temperature and room temperature foil gages, and several special cement kits. Baldwin-Lima-Hamilton Corp.

Circle 586 on page 19

Thermostats

Hermetically sealed and semienclosed Stemco type C thermostats for controlling low wattage electrical circuits are detailed in bulletin 5000. Operating temperatures range from −10 to 300° F. Electrical rating is up to 3 amp on 125-v ac. 2 pages. Stevens Mfg. Co.

Circle 587 on page 19

Mechanical Force Gages

Usable for measuring both tension and compression loads up to 200 lb, mechanical force gages are accurate instruments for all types of testing and calibrating work. Available capacities and typical uses are covered in bulletin 750c. 6 pages. Hunter Spring Co., Apparatus Div.

Circle 588 on page 19

Washers

Dimensions, prices and available finishes are but a few of the data contained in catalog 54 on standard and special-purpose washers. Listed is proposed American Standard for apparatus and plain washers. 8 pages. Joliet Wrought Washer Co.

Circle 589 on page 19

Small Motors & Counters

Fractional-horsepower shaded-pole motors, equipped with gear reducers and producing output speeds up to 100 rpm, are designed for operation on voltages from 6 to 240 v ac. Torques range to 1/30-hp. Illustrated bulletin also describes counters which can be driven by these motors. 12 pages. Electro-Counter & Motor Co.

Circle 590 on page 19

Silicone Lubricants

Silicone lubricants help solve lubricating problems involving high temperature and oxidation. These stable lubricants combine high flash points, low freeze points and relatively constant viscosity. Complete application information is given in bulletin 6-101. 8 pages. Dow Corning Corp.

Circle 591 on page 19

Airborne Switches

"Enclosed Switches for Airborne Equipment" is title of catalog 77 which shows contact arrangements, and lists characteristics and electrical ratings for all types of cam, lever, button, toggle and other actuated types of controls. All are protected from physical damage and sealed against dirt and moisture. 24 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 592 on page 19

Ball Bearings

Dimensional and series indexes; visual guide to bearing types, characteristics and applications; and a separate index to selection and engineering data are contained in the Barden precision ball bearing catalog. Cutaways and cross-sections are included, along with many data in chart and table form. 64 pages. Barden Corp.

Circle 593 on page 19

Rotary Gang Slitters

Illustrated bulletin 569 on "Slitting Lines" includes pictures of slitting operations as well as tables of cutting capacities and machine specifications. Both sheet and coil slitting methods are summarized. 16 pages. Stanat Mfg. Co.

Circle 594 on page 19

Stainless Bar & Wire

Standard and special grades of stainless steel bar and wire for fabrication into all types of products is covered in bulletin P.O.2856. 4 pages. Armco Steel Corp.

Circle 595 on page 19

Electrical Controls

What it is, how it works, what's available and where to use information is content of bulletin GEA-6372 entitled "General Purpose Control Operation and Application Manual." Data are given on starters, pushbuttons, relays, limit switches, solenoids, pressure and vacuum switches, float

Illustrated—New 9700 Series Piggy Back Hydraulic Control Valve.

Look to Logan

the ultimate in hydraulic valve design

FREE SEND FOR THE "LOGAN CALCULATOR"

A gift to you from Logansport Machine Company upon request.

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811 CENTER AVENUE, LOGANSPORT, INDIANA

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NAME_____ TITLE_____

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Circle 463 on page 19

switches and pressure governor. 32 pages. General Electric Co., General Purpose Control Dept.

Circle 596 on page 19

Silicone Products

"1957 Reference Guide to Dow Corning Silicones" briefly describes and gives properties of almost 150 silicones which offer solutions to difficult design, production and maintenance problems. Types include adhesives, dielectrics, defoamers, release agents, tapes, gums, protective coatings, water repellents and molding compounds. 12 pages. Dow Corning Corp.

Circle 597 on page 19

Wire Rope

Properties of PREmium Whyte Strand plow steel wire rope are subject of bulletin 5685. Shown are uses of braided and single wire rope slings in construction and materials handling. 4 pages. Macwhyte Co.

Circle 598 on page 19

Propellant Valves

Details of a complete series of high pressure, linked, multiline propellant valves for control of fuel-oxidizer flow in airborne or ground installations are presented in Tech Bulletin 24. 4 pages. Hydromatics, Inc.

Circle 599 on page 19

Fluorescent Lamps

Features of the new VHO (Very High Output) fluorescent lamps which reportedly produce double the light output of equivalent size Rapid Start lamps are related in bulletin FL-579. Lamps are usable in indoor and outdoor fixtures. 4 pages. Sylvania Electric Products Inc.

Circle 600 on page 19

Laminated Shims

Technical data for laminated shims of brass, mild steel, stainless steel and aluminum are updated to current design and installation requirements in illustrated catalog. Also itemized are sizes and prices of cup shims of solid brass to fit standard tapered roller bearings of all sizes. 8 pages. Laminated Shim Co.

Circle 601 on page 19

Fluid Drives

Low starting current, overload protection, smooth starting, shock absorption, rapid cycling and controlled acceleration are advantages of Gyrol fluid drives described in bulletin 9119. Designed for constant speed, hard-to-motor jobs, these drives are offered in ½ to 25-hp ratings. 16 pages. American Blower Corp., Hydraulic Coupling Div.

Circle 602 on page 19

Hydraulic Check Valve

Engineered for aircraft service, series 5900 rotary controllable check valves operate at pressures to 3000 psi. They conform to military specifications and are available in ¼, ½ and ¾-in. tube sizes. Full information is given in bulletin 5900. 2 pages. Aircraft Products Co.

Circle 603 on page 19

Positive Displacement Pumps

Engineering and selection guidance on complete line of model R automatic reversing pumps is afforded by catalog 105. Suitable for lubrication, hydraulic power, coolant and circulating service, pumps are made in range of types and capacities. Charts and tables give performance data. 12 pages. Tuthill Pump Co.

Circle 604 on page 19

Bearings, Hangers & Collars

Power transmission equipment described in bulletin 2028 includes Pioneer steel shaft hangers, hanger bearings, split journal bearings, pillow blocks, and solid and split cast iron collars. Dimensions are given. 4 pages. Standard Pressed Steel Co.

Circle 605 on page 19

Boss Fittings

Line of SAE Boss fittings and O-ring adapters is described in illustrated catalog. Sizes and styles are available to suit every need. 12 pages. Anchor Coupling Co.

Circle 606 on page 19

Throwaway Cutting Inserts

New Met high-velocity cutting material has been developed to cut most metals at speeds in excess of 1000 fpm. Performance data are listed for several typical jobs involving various difficult-to-machine materials in illustrated bulletin. 4 pages. Newcomer Products, Inc.

Circle 607 on page 19

Hydraulic Thrust Unit

Powerful hydraulic output thrust or torque is developed from low-level electrical input signals from various sensing elements by the Askania Electrojet, an electrohydraulic unit. Applications include positioning servos, floating control systems and similar operations. Details are given in bulletin 38.1. 16 pages. Askania Regulator Co.

Circle 608 on page 19

Reproduction Materials

Eight new products are among photographic reproduction materials for drawings described in catalog K. Included are silver-sensitized papers, vellums, films and tracing cloths for making negatives, prints and positive-to-positive prints. Data on selecting materials are included. 16 pages. Grant Photo Products, Inc.

Circle 609 on page 19

Coolant Filters

Description of Delpark self-cleaning, continuous automatic coolant filters for use on Landis precision grinders is found in illustrated folder. Operation of the devices is detailed. 4 pages. Industrial Filtration Co.

Circle 610 on page 19

Stampings & Moldings

Examples of economically produced short-run metal stampings and plastic moldings are shown in bulletin F-225. Also covered are pneumatic press die cushions, drawn shell trimmer, overload pitman, spacing collars and layout fluid. 12 pages. Dayton Rogers Mfg. Co.

Circle 611 on page 19

Wire Connectors

Factual information on field uses of pres-SURE-connectors as used for solderless wire splicing and terminating is content of illustrated pocket-size booklet. 40 pages. Buchanan Electrical Products Corp.

Circle 612 on page 19

Weldments

How weldment problems on units weighing up to 25 tons are solved by techniques employed by this company are outlined in illustrated folder. 4 pages. H. F. Butler, Inc.

Circle 613 on page 19

Magnetic Laminations

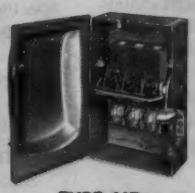
Supplement to magnetic laminations catalog ML-201 gives physical lamination constants and core stack design factors for new high permeability laminations. 4 pages. Magnetics, Inc.

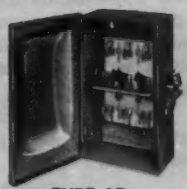
Circle 614 on page 19

Die Casting

"Die Casting—Molten Metal to Finished Part—Direct" is an illus-

FIRST with a COMPLETE LINE OF SAFETY SWITCHES to meet the NEW NEMA STANDARDS





TYPE HD TYPE ND TYPE LD

• The table below shows Square D switches meeting new industry specifications. Notice how they clarify conflicting features which existed under old designations. Notice, too, that they establish a new, heavy-duty industrial switch, Type HD.

One important thing which remains unchanged is the **DESIGN LEADERSHIP** which has made **SQUARE D SAFETY SWITCHES** industry's overwhelming **FIRST** choice for more than fifty years. Compare them, feature for feature. They cost no more, why settle for less?

DESCRIPTION	HEAVY DUTY New	NORMAL DUTY formerly Types H, S, or A	LIGHT DUTY formerly Types D or G
Rating-Ampere Voltage	30—600 250 or 600V AC, DC	30—1200 250 or 600V AC, DC	30—200 250V AC
Enclosure	NEMA 12 • Industrial Use (Gasketed) NEMA 4 & 5 • Water-tight & Dust-tight NEMA 7 • Explosion-resisting Class I—Group D NEMA 9 • Explosion-resisting	NEMA 1 • General Purpose NEMA 3R • Raintight	NEMA 1 • General Purpose NEMA 3R • Raintight
Horsepower Rating	NEC Fuse Ratings Dual-Element Fuse Ratings	NEC Fuse Rating Dual-Element Fuse Ratings	NEC Fuse Rating
Operating Mechanism	Quick-Make, Quick-Break Independent of Handle	Quick-Make, Quick-Break Independent of Handle	Positive Make, Positive Break Spring Assisted
Cover	Interlocked & Padlock Attachment	Interlocked & Padlock Attachment	Padlock Attachment
Plating—Current Parts	Extra-Heavy Silver	Silver	
Endurance	Maximum Endurance Far Exceeds UL Standards	Exceeds UL Standards	Meets UL Standards

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE!

SQUARE D COMPANY

trated booklet which discusses this production method as it affects product design, machining requirements and surface finish. Basic steps, dies and production machines, various alloys and typical products are covered. 28 pages. American Zinc Institute, Inc.

Circle 615 on page 19

Steel Tube Fittings

Engineering data on 7000 and 8000 series Ermeto flareless and Flare-Twin SAE 37-degree flare (JIC) hydraulic tube fittings are found in steel tube fittings catalog. Specifications, assembly instructions and other data are included. 48 pages. Weatherhead Co., Fort Wayne Div.

Circle 616 on page 19

Ultrasonic Brazing

Sonobraze ultrasonic equipment for fluxless brazing and for metal coating is described and illustrated in bulletin SBR-6A. Its operation and advantages are outlined. 4 pages. Aeroprojects Inc.

Circle 617 on page 19

Phosphor Bronze

Physical characteristics, processing and applications of high tolerance phosphor bronze in thicknesses as low as 0.0005-in., ±0.0001-in. are contained in data sheets. Material has high strength, long fatigue life, good electrical conductivity, good corrosion resistance. 4 pages. American Silver Co.

Circle 618 on page 19

Foam Polyethylene

Gasketing, linings, insulation and cores are among uses for Agilene-F, an expanded foam polyethylene described in catalog sheet. Its composition and chemical resistance are detailed. American Agile Corp.

Circle 619 on page 19

Unit Heaters

Specifications, operating characteristics, installation and application data, piping diagrams, ductwork suggestions, sound ratings and wiring diagrams are among information on Venturafin unit heaters contained in vest pocket handbook. 64 pages. American Blower Corp.

Circle 620 on page 19

Flexible Couplings

Shock absorbing roller chain flexible couplings which are quickly assembled or disassembled to shafts are subject of catalog CP1-56. Engineering data and ratings for types and sizes offered are included. 8 pages. Acme Chain Corp.

Circle 621 on page 19

Panel Meters

Available ranges and prices for voltmeters, milliammeters, microammeters, ammeters, wattmeters, ac voltmeters, dc galvanometers, rf ammeters, volume level indicators and other instruments are included in illustrated bulletin 2057. Shunts and current transformers are also covered. 6 pages. Simpson Electric Co.

Circle 622 on page 19

Teflon Equipment

Teflon as it applied to company's equipment is described and its properties given in bulletin T-50. Products include thin and heavy-walled tubing and rod, steel pipe lining, insulated wire, machine parts and sheet. 4 pages. Haveg Industries, Inc., Halocarbon Div.

Circle 623 on page 19

Hook-Up Wires

Series of single conductor, 600-v, high temperature, aircraft hook-up wires, designed to meet military specifications, are described in bulletin 1906. Sizes from 22 to 12 gage have −68 to 410° F operating range. 2 pages. Revere Corp. of America.

Circle 624 on page 19

Pressure Transmitter

Style H electric low differential pressure transmitter with ranges of 0 to 2, 4, 6, 8 and 10 in. of water and working presure of 50 psi is described in bulletin 501. Illustrations show construction and operation. Burgess-Manning Co., Penn Instruments Div.

Circle 625 on page 19

Galvanometers

Type 7-300 galvanometers find time-correlation between electrical signals, measure amplitude and duration of minute signals, test aircraft, industrial or power generating equipment and determine long-term or transient load forces. Bulletin 1528 describes these meters. 12 pages. Consolidated Electrodynamics Corp.

Circle 626 on page 19

Thermocouple Components

Specification folder S005-1 on QuiK-Konnect thermocouple components describes system of connectors for thermocouples and lead wires. Plugs and jacks, jack panel, adapters and cable clamps are covered. 4 pages. Minneapolis-Honeywell Regulator Co., Industrial Div.

Circle 627 on page 19

Potentiometers

Improved operating characteristics of Beckman/Helipot series B potentiometers are listed in data sheet 54-18. They have more favorable values for linearity tolerances above 999 ohms. 2 pages. Helipot Corp.

Circle 628 on page 19

Built-In Coolant Filters

Norton type CM-1 heavy duty semiautomatic multiwheel grinder which features an automatic self-cleaning continuous filter built into its base is subject of illustrated bulletin. Filter operation is outlined. 4 pages. Industrial Filtration Co.

Circle 629 on page 19

Powdered Metal Parts

Comprehensive brochure points up cost and performance advantages of powdered metal parts. Featured is a general guide for brazing, welding, soldering, peening, riveting, machining and other secondary operations. 12 pages. Lux Clock Mfg. Co., Powdered Metal Parts Div.

Circle 630 on page 19

Thermostats

Stemco type B thermostats for table appliances and tip-over safety switches are descrribed and illustrated in bulletin 9000. Ratings, specs and dimensional sketches are included. 2 pages. Stevens Mfg. Co.

Circle 631 on page 19

Time Delay Relays

Two bulletins, TD404 and TD405, respectively describe surface mounting and flush mounting types of dial adjustable time delay relays. Timers, used for frequent changes in time setting, come in ac, dc and 400-cycle types. 2 pages each. A. W. Haydon Co.

Circle 632 on page 19

Steel Springs

Technical data provided in bulletin RS-2 on production of hot and cold-wound steel springs includes formulas and specifications for helical extension springs and volute and Belleville disk springs. Design recommendations and physical properties are given. 16 pages. Alco Products, Inc.

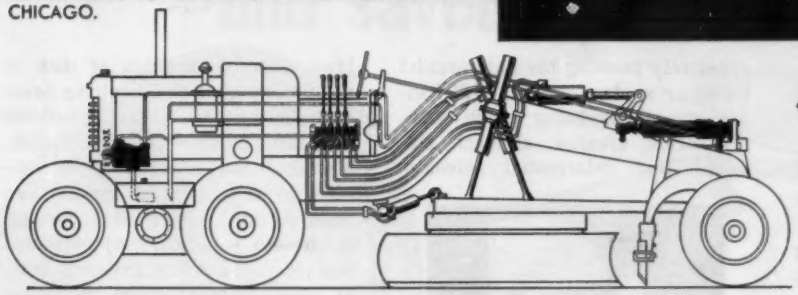
Circle 633 on page 19

"Nobody puts a fine painting in a dime-store frame." When you see a piece of construction equipment with Vickers Hydraulics, you know it is a "quality" machine throughout.

Vickers provides all the inherent advantages of hydraulics and MUCH MORE: (1) the benefits of a nation-wide and full-time field engineering and service organization of unequalled experience; (2) a complete line of equipment enables Vickers to take UNDIVIDED system responsibility thus eliminating any risk of incompatibility of hydraulic components; (3) a hydraulics school for free training of customers' maintenance personnel.

SEE VICKERS HYDRAULICS IN SIMULATED ACTION IN BOOTH 219 AT THE ROAD SHOW, JANUARY 28 TO FEBRUARY 2, AT INTERNATIONAL AMPHITHEATRE, CHICAGO.

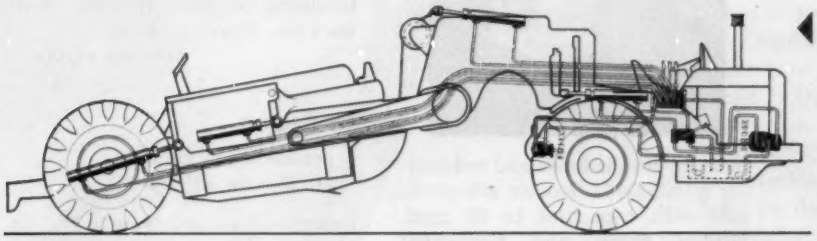
VICKERS HYDRAULICS *means* "QUALITY" CONSTRUCTION EQUIPMENT



Motor grader uses Vickers Hydraulics for:

- maximum blade utility
- accurate and effortless tool adjustment
- positioning scarifier
- convenience of control to operator

Hydraulic motor (not shown) rotates blade on circle. Hydraulic power steering is separate circuit. Central hydraulic system is applicable.



Scraper has VARIABLE rate hydraulic power steering provided by:

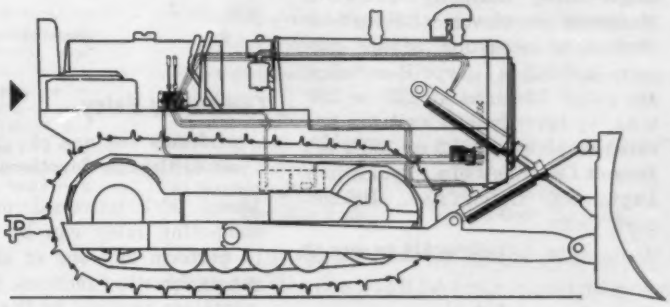
- Vickers Double Vane Pump
- Vickers Metering Control Valve
- Vickers Circuit-Splitting Unloading System
- Vickers Overload Relief Protection

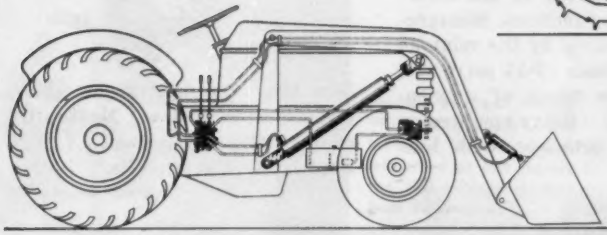
Vickers Single Vane Pump supplies power for:

- Fast actuation of bowl
- Fast apron manipulation
- Fast—Positive ejector action

More Work—Less Time—Minimum Maintenance.

Vickers Hydraulics provides fast lifting and angling of bulldozer blade along with exclusive "feathering" ability. Additional tractor attachments added later can be hydraulically controlled by simply adding sections to existing control valve thus eliminating necessity of mounting separate valves.





Fast, easy and dependable operation of front end loader utilizes Vickers Balanced Vane Pump (with inherent automatic wear compensation) and Vickers Two-Section Directional Control Valve. Note simplicity of installation.

SEE VICKERS BOOTH 219
A. R. B. A. ROAD SHOW • JAN. 28-FEB. 2
INTERNATIONAL AMPHITHEATRE, CHICAGO

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7695

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

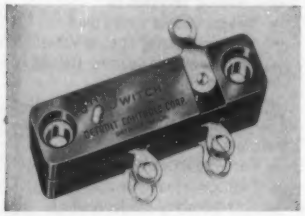
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Stacking Switches

permit multiple switching with single actuation

Precision stacking of Class 1 TyniSwitches allows a single actuator switch to control two or more independent circuits with resulting space savings. Each individual switch action can be double-throw, single-throw normally open, or



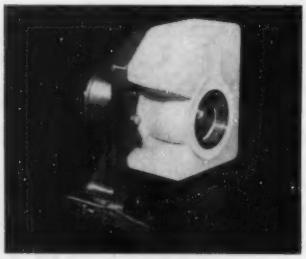
single-throw normally closed. Maximum pin movement from first contact to actuation of all contacts is 0.015-in. Type B switches are rated 15 amps at 125 or 250 v ac, ½ hp. Type D switches are rated at 10 amps, 125 or 250 v ac. **Detroit Controls Corp.,** TyniSwitch Dept., 800 Union Ave., Bridgeport, Conn.

Circle 634 on page 19

Corrosionproof Pump

handles difficult fluids to 300 F

Corrosive fluids are in contact with fluorocarbon materials only in a new pump, enabling it to pump extremely corrosive fluids at temperatures to 300 F. Shaft seals and stuffing boxes are eliminated and fluids or slurries are isolated in a passage formed by outer surface of Kel-F liner and inner surface of Teflon or Kel-F body block. Operation of the pump is by eccentric shaft and rotor assembly rotating within the liner and progressively pushing the fluid around its outer surface. Pump will handle strong oxidizing acids, mineral acids, alkalies, aliphatic solvents, and chlorinated solvents,



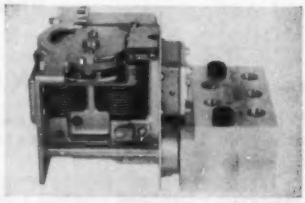
fuels, hydraulic fluids and red fuming nitric acid. Models are available with capacities to 20 gpm. **Vanton Pump and Equipment Corp.,** 201 Sweetland Ave., Hillside, N. J.

Circle 635 on page 19

Computing Relay

performs any one of six arithmetic functions

Model 56-1 universal pneumatic computing relay can be adjusted to perform any one of six different arithmetic functions. Measurements are received by the relay as pneumatic signals (3-15 psi); output is also in terms of a pneumatic pressure. Relay operates on force-balance principle, with four



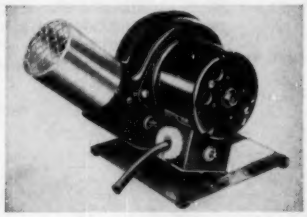
bellows positioning a floating disk that acts as flapper of a flapper-nozzle detector. Pressures in bellows establish position of disk in relation to nozzle. Resulting pressure change in feedback bellows maintains balance position of disk. Manifold has connections to bellows so measurement signals are received and computed according to desired equation. Applications include fuel-air flow ratioing, boiler swell compensation and flow totalizing on multiple lines. **Foxboro Co.,** Foxboro, Mass.

Circle 636 on page 19

Air Heater

produces air volume of 50 cfm at 300 F

Designed for continuous duty, this blower unit electrically heats air to accelerate drying processes and for localized heating. Air temperature at nozzle is 300 F and air volume produced is 50 cfm. Air velocity is 2000 fpm; heat input is



3400 Btu. Unit operates on 115 v, 60 cycle ac at 1000 w. **Master Appliance Mfg. Co.,** Dept. 7, 536 Fourth St., Racine, Wis.

Circle 637 on page 19

Mercury Relays

115-v unit handles 6900-w loads

Single-pole, single-throw normally open EME-1 and HDL-1 mercury plunger relays, for use in lighting controls, panelboards, ovens, molding machinery and furnaces, safely

Bob Rossi, Chief Engineer, tells
Roy Johnson, Plant Manager

"We switched to Formbrite —and saved 12 cents apiece!"

.032" gage 70-30 Formbrite is used for this 4½" diameter rearview mirror head shown full size. Strip is $5^{1}\frac{3}{32}$" wide supplied in heavy coils for long press runs. Copper, nickel and chromium plating on a solid brass base provides a bright, rustless, long-lasting outdoor finish.

Peerless Rearview Mirrors. "Flight-Wing," below, and the newer "Director" model, left. Housings and mounts are chromium-plated zinc-base die castings.

This easy-to-polish, superfine-grain drawing brass has been slashing finishing costs in plant after plant, on all kinds of jobs. Now Peerless Accessories Co., of Mount Holly, N. J., reports:

"To our line of lighting and safety automotive accessories, we've recently added two rearview mirror assemblies. We had been using regular drawing brass for the dished head until your representative persuaded us to try Formbrite. Here are the results, based on a very careful cost study:

Finishing procedure using regular drawing brass	Present procedure using Formbrite*
1) Grease grinding or "cutting"	Not necessary with Formbrite
2) Buffing	Light buff
3) Copper strike	Copper strike
4) Nickel plate (.00045")	Bright nickel plate (.0003")*
5) Buffing nickel	Not necessary
6) Chromium plate	Chromium plate
Cost 27¢ each	**Cost 15¢ each**

"That's a saving of 12 cents apiece. Multiply it by 3,000 to 4,000 a day and it becomes important money!"

*Formbrite's superfine grain made possible a lighter but equally serviceable plate of *bright* nickel

Surprisingly, Formbrite doesn't cost a penny more. Find out for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you make a better product at lower cost. Write for Publication B-39. Better yet, ask us about a sample lot. The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. AB70

Formbrite FINE-GRAIN DRAWING BRASS

an ANACONDA® product
made by The American Brass Company

Circle 466 on page 19

DPS *has*

the technical know-how to "*engineer*" more speed and profit into your assembling operations.

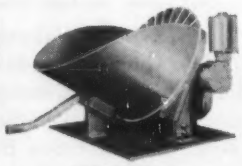
● The signal success of DPS trained engineers in adapting power equipment to the individual feeding and assembling needs of industrial plants everywhere is assurance that they can likewise solve your special problems. In our broad line of

SELECTIVE PARTS FEEDERS
POWER SCREWDRIVERS
SPECIAL ASSEMBLING MACHINES

equipment can be selected, and custom features incorporated, to fit your requirements. Plan now to use DPS modern assembling methods. Tell us your set-up. Write for catalog and further details.

POWER SCREWDRIVERS
An extensive, versatile line in both bench and pedestal types.

BOWL FEEDER
Electrical vibratory type to feed parts that cannot be tumbled.



BARREL FEEDER
with stationary ring cover for heavy-duty production.

BARREL FEEDER
Popular motorized type, for parts requiring critical selection.

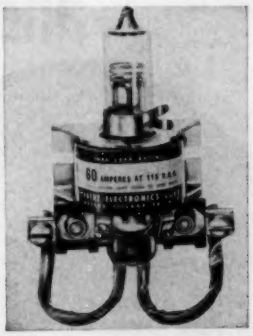
DETROIT POWER SCREWDRIVER CO.

2801-A W. FORT STREET DETROIT 16, MICHIGAN

Circle 467 on page 19

New Parts

carry tungsten surge currents of up to ten times steady state current without failure, flicker or sticking. Hermetically sealed units have mercury-to-mercury contact design and are UL approved for tungsten lamp loads of either 4000 or 6900 w at 115 v, 50/60 cycles. Relays provide stable contact re-



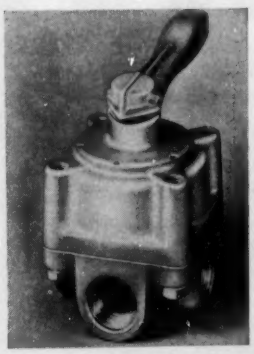
sistance of approximately 0.001-ohm, are recommended for a maximum of 60 complete operations per minute. Terminal connections are in front for ease of installation. Moisture-resistant cotton interweave coils are available in various stock voltages or are made to meet specifications. Weight of the relays is 14 and 16 oz. **Ebert Electronics Corp.**, 212-26 Jamaica Ave., Queens Village 28, N. Y.

Circle 638 on page 19

Pneumatic Valve

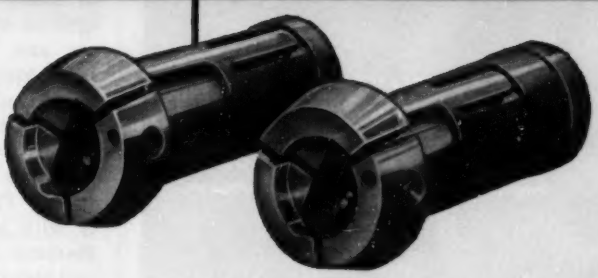
four-way unit for 250-psi service

This 1½ in. four-way valve, for use where positive shut-off is important, incorporates a pressure-



balanced, self-aligning tubular sealing ring in contact with an optically flat porting disk containing a flow passage. Square ex-

These intricate, close-tolerance collets weigh less than 10 pounds—are worth nearly $800 each. The manufacturer states: "Our experience with various collet steels proves Crucible collet steel to be superior for flexibility and ability to hold its shape during heat treatment."



for minimum distortion after heat treatment

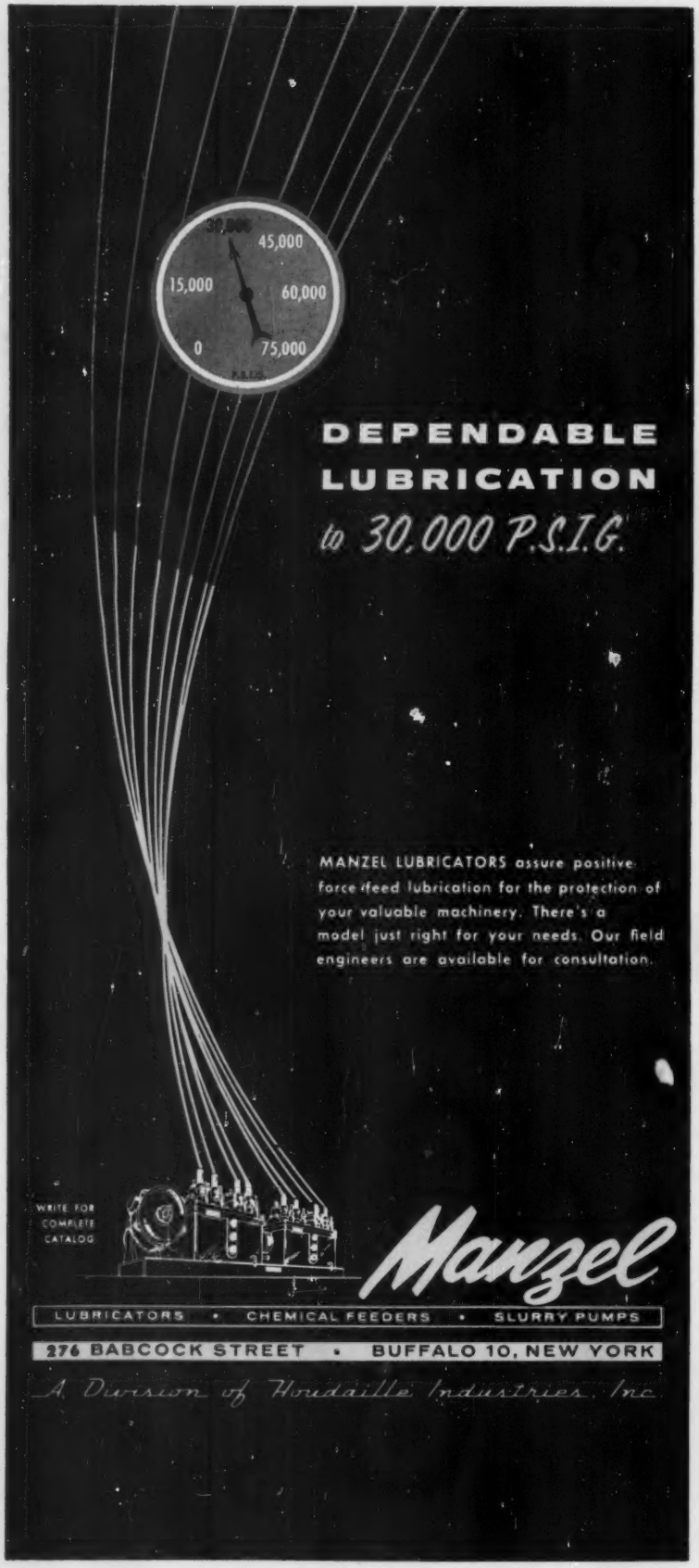
These collets are used in machining the anchoring end of jet engine turbine blades, while locating the part from reference points on the airfoil section of the blade. It's a job that demands a steel which will not distort during heat treatment. The collet head is heated to Rockwell 58-60 C—the body tempered to 35-38 C.

The steel used is a special Crucible non-warping alloy collet grade. The collet manufacturer, Balas Collet Mfg. Co., Cleveland, Ohio, reports: *The extreme accuracy built into these collets while they are still in the soft state shows less than .0005" distortion on any dimension after heat treatment.*

Crucible collet steel was developed specifically for spring collets—or *any* parts with rigid requirements of excellent machinability and high attainable hardness. Other properties—in almost limitless combination—can be had in other Crucible alloy grades. To see what information is available on these alloy steels—or *any* Crucible special steel—get your copy of the *Crucible Publication Catalog*. Write *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America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15,000
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New Parts

ternal corner of the sealing ring wipes the rotor clean so that dirt cannot enter between sealing surfaces to cause scoring and destroy sealing qualities. With each actuation the seals lap themselves to a more perfect seal; the small amount lapped away after long service is taken up by a back-up spring. Valve is for use in zero to 250-psi service. Noncorrosive materials are used for all valve parts; sealing ring, shaft and detent ball are stainless steel. Valve body and housing are aluminum. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle 639 on page 19

Synchronous Motor

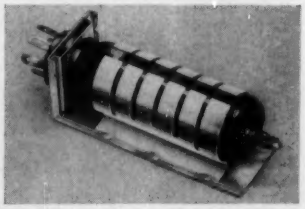
for high-temperature timers

This synchronous motor has applications in timers subjected to temperatures to 150 F, as in ranges, washers and dryers, animated displays, packaging and plastics molding machinery. It can also be used in timers incorporated in diesel generators, jet aircraft ignition systems, printing machinery and circuit breakers. Bearings require no lubrication. Rounded ends of rotor shaft ride in cup-shaped bearings, with a spider spring mount taking up end play on pivots. Shaft vibration is eliminated. First pinion is cut integrally with rotor shaft. Small pitch diameter permits low fpm speed and slower speed of gear reduction unit. **Lux Clock Mfg. Co.,** 95 Johnson St., Waterbury, Conn.

Circle 640 on page 19

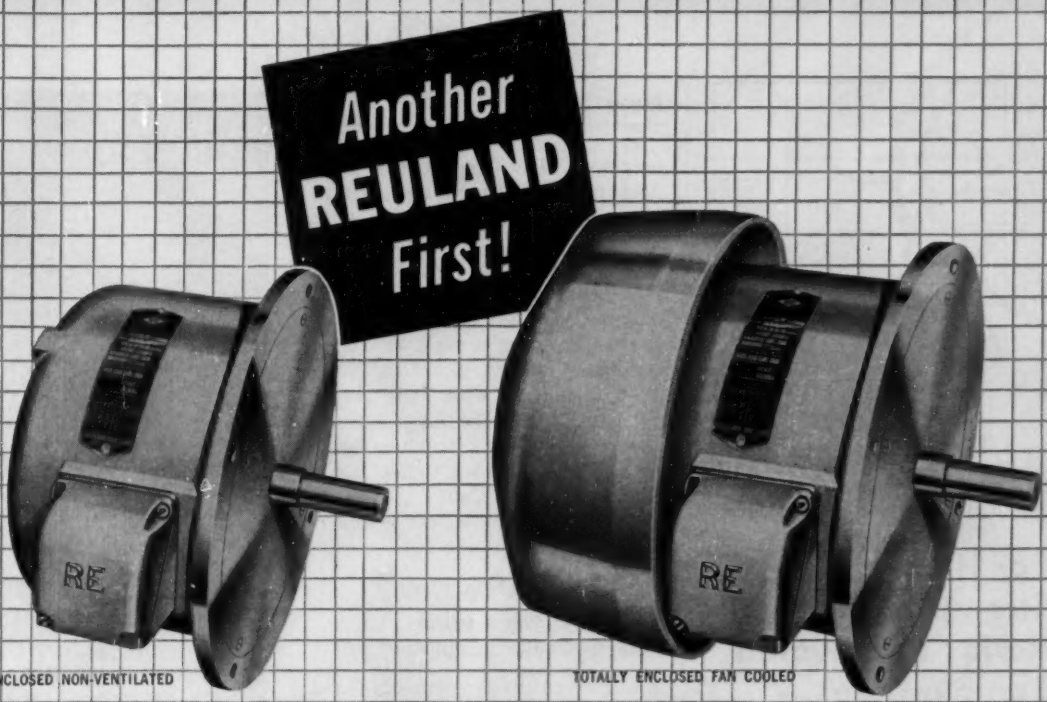
Miniature Tube Clamps

provide rigid mount to withstand severe vibration



These miniature clamps, designated 6A-4 and 6A-5 Kool Klamps, have integral sockets built into a rigid socket mount. They offer

Circle 469 on page 19



TOTALLY ENCLOSED NON-VENTILATED

TOTALLY ENCLOSED FAN COOLED

MOST BEAUTIFUL MOTORS IN ALL THE WORLD...

NEW REULAND PRECISION MOTORS FOR MACHINE TOOLS

Designed especially for machine tool manufacturers

Reuland precision motors were developed only after giving a lot of careful thought to the problems of the machine tool industry. They are not just another line of motors that can be "made to fit," but rather, a complete new type especially made for machine tool manufacturers.

They are available in T.E.N.V. and T.E.F.C. types. Small, compact and featuring the very latest in lightweight materials.

For good looks and precision operating characteristics, there is nothing on the market to equal these jewel-like units.

Precision balance

Reuland motors are built to precise specifications like a fine tool. Each unit is dynamically balanced at the factory to assure vibrationless operation.

Heavy-duty ball bearings, located at each side of the rotor, assist in maintaining this characteristic which is so vital to precise work. Exact tolerances are likewise maintained throughout final assembly.

Low inertia rotor

The radial air gap design of these motors permits the use of a lighter weight, low inertia rotor. This light weight, low inertia feature assures smooth starts and quick stops.

This rotor is also of a special narrow design which has shortened up the overall length of the motor to give a thinner, "wafer" effect.

Smooth-finished castings —pleasing lines

The smoothly finished surfaces of Reuland machine tool motors are a match for the most expensive tool. All castings are specially processed for smoothness and are given a baked enamel finish.

This fine-quality finish, together with the motors' naturally pleasing lines, assure a harmonious blend with the lines of every machine tool on which they are mounted. (When desired, the motor's frame size can even be varied to fit an *exact* contour of the machine.)

Other Reuland firsts!

1. Motor with internal fluid coupling
2. Spline-coupled hydraulic pump motor
3. Foot-mounted disc type magnetic brake with self-contained bearings and shaft
4. "Through-Shaft" magnetic disc brakes
5. Slip Ring motors in small #66 frames
6. All-aluminum motor frames
7. "Xpandable" motor design

Use these other free Reuland Services

Special-Motor Library

Don't ever pay for special-motor development costs before you check this free library. Contains valuable data on hundreds of unique, specially designed motors. Send for free "how to use" booklet.

Standard Motor Catalog

Contains engineering information on Reuland's complete line of standard motors and motoreducers. Sent free on request.

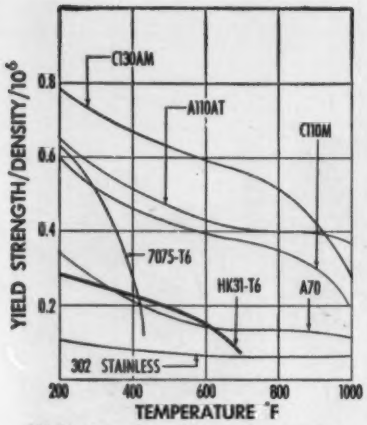
REULAND MOTORS

REULAND ELECTRIC COMPANY

Western Division: Alhambra 66, California
Eastern Division: Howell 66, Michigan

Distributors in all principal cities

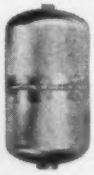
Circle 470 on page 19



Yield strength, weight vs. temperature.

For High Strength-to-Weight Ratios at Elevated Temperatures— TITANIUM and MAGNESIUM

The experience, the specialists, the equipment-and-facilities to design and produce the *very difficult* fabrication and assembly work in these and other light metals—you'll find at B&P.


To make this titanium pressurized tank, B&P welds two cylinders. Each is drawn in one operation. Tank withstands 5000 psi pressure.

Magnesium turret enclosure for a bomber. Design, lofting, prototypes, production fabrication and assembly are all done by B&P.

ENGINEERING FACILITIES IN DETROIT AND LOS ANGELES .. Write for Titanium and Magnesium engineering data—also folder on B&P's facilities to handle tough jobs.

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56 A

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New Parts

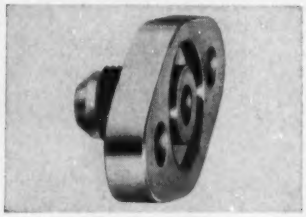
maximum envelope contact and heat conductivity. Silver sleeves are soldered to silver-plated copper sleeves, in turn soldered to silver-plated hard-drawn copper bases. MIL approved sockets are mechanically locked into the copper bases, providing a rigid mount to withstand severe vibration. The 6A-4 is for use with 7-pin miniature tubes and the 6A-5 for use with 9-pin tubes. **Birtcher Corp.,** Industrial Div., 4371 Valley Blvd., Los Angeles 32, Calif.

Circle 641 on page 19

Tubing Connection

connects flared tubing to hydraulic equipment

Flange-type fitting connects flared tubing to hydraulic equipment such as pumps, compressors and engines. A pad on the body of



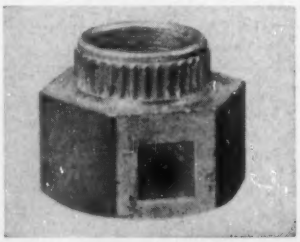
the equipment can be designed to receive the flange. Fitting is available in a wide range of tube sizes and with a variety of gasket materials. **H. K. Porter Co. Inc.,** W-S Fittings Div., P. O. Box 95, Roselle, N. J.

Circle 642 on page 19

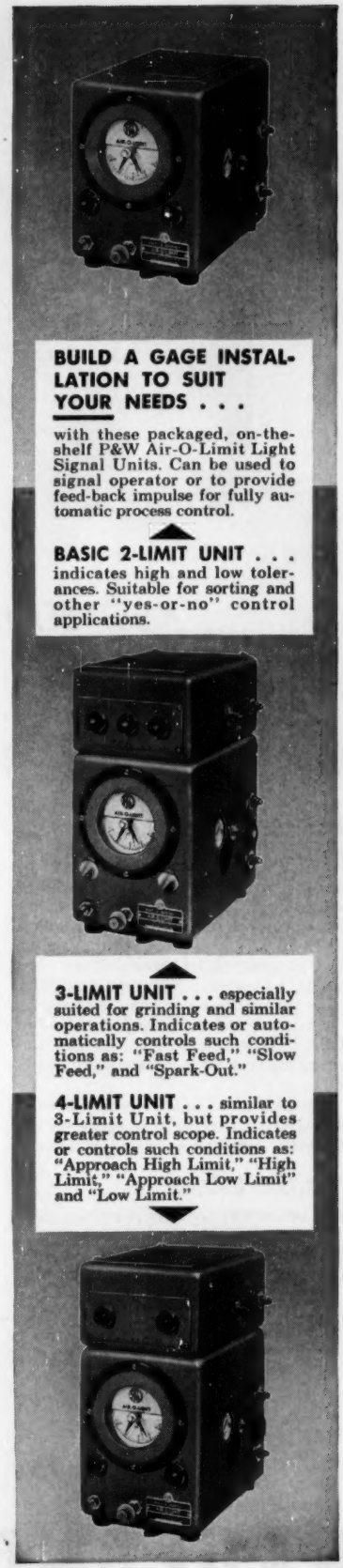
Self-Locking Clinch Nuts

are now available in sizes to No. 0

Nylok clinch nuts resist severe vibrations and temperatures from



—70 to above 250 F. The nuts provide excellent reusability and meet torque requirements of AN-N-5



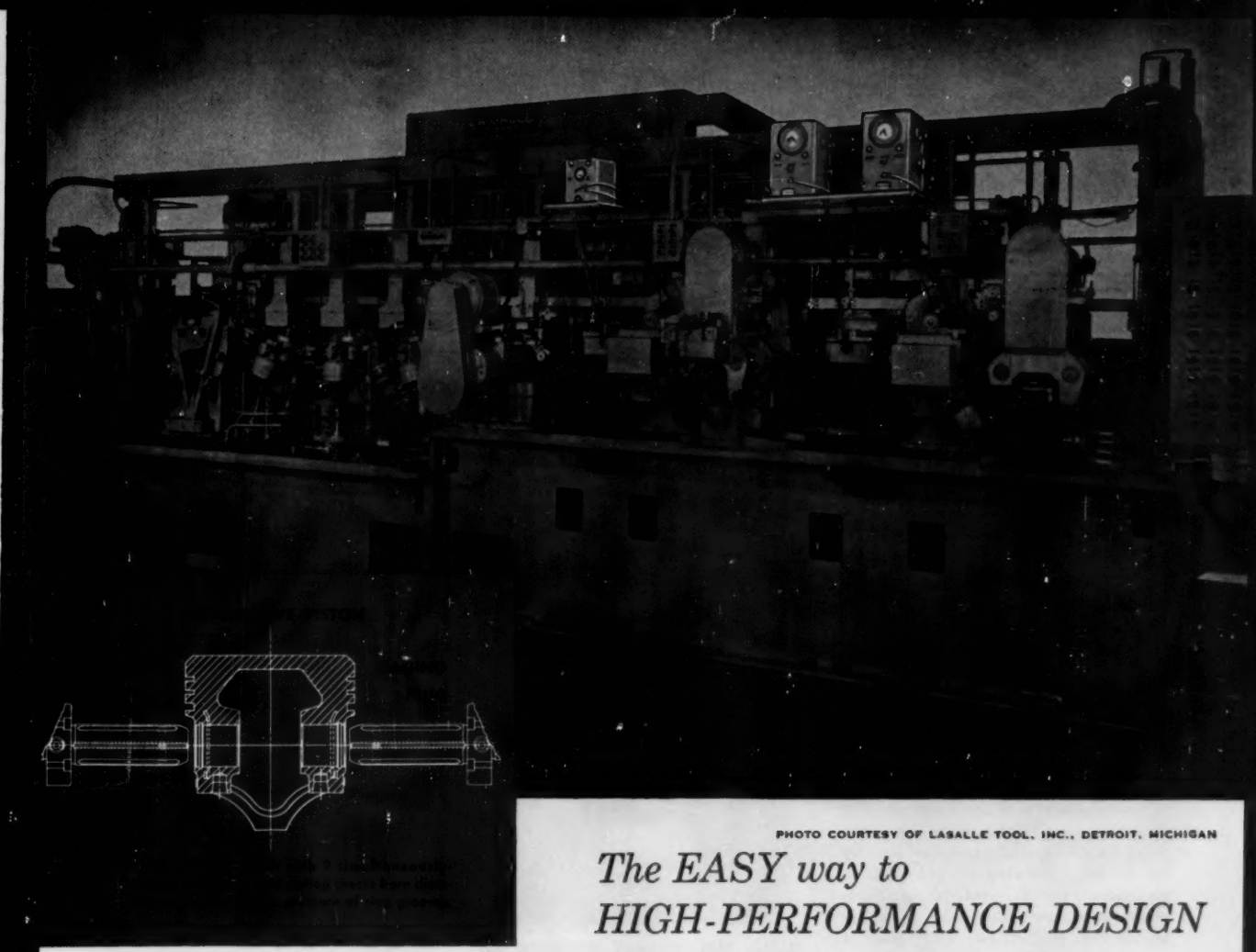
BUILD A GAGE INSTALLATION TO SUIT YOUR NEEDS . . .

with these packaged, on-the-shelf P&W Air-O-Limit Light Signal Units. Can be used to signal operator or to provide feed-back impulse for fully automatic process control.

BASIC 2-LIMIT UNIT . . . indicates high and low tolerances. Suitable for sorting and other "yes-or-no" control applications.

3-LIMIT UNIT . . . especially suited for grinding and similar operations. Indicates or automatically controls such conditions as: "Fast Feed," "Slow Feed," and "Spark-Out."

4-LIMIT UNIT . . . similar to 3-Limit Unit, but provides greater control scope. Indicates or controls such conditions as: "Approach High Limit," "High Limit," "Approach Low Limit" and "Low Limit."



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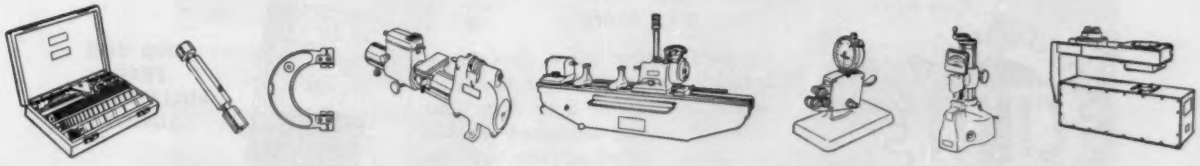
The EASY way to HIGH-PERFORMANCE DESIGN

PRATT & WHITNEY STANDARD, ON-THE-SHELF GAGE CONTROL UNITS

INCREASED OUTPUT RATES, INSURED ACCURACY, REDUCED REJECT RATES . . . these are the plus-performance factors that On-Machine or Automation Gaging can bring to a wide variety of production machines. And now, these standard P&W Packaged Units . . . with appropriate tooling . . . make it possible to provide an installation exactly tailored to your needs and easy to integrate into your present designs *without* the expense or delays required to engineer or construct special controls.

For example, these P&W Packaged Units made it easy to provide automatic on-machine gaging for this special, high-speed automotive piston machine produced by LaSalle Tool, Inc. Two P&W Air-O-Limit Carbide Gage Plugs are arranged to check the ID of both wrist pin bores on the pistons automatically. Lights on the P&W Control Units signal the operator if tolerances are exceeded. A second set of gage plugs similarly checks bores for the presence of snap ring grooves. If desired, control units can be arranged to shut down the machine automatically when an imperfect part is detected. Whatever *your* requirements, P&W can supply gaging equipment exactly right for the job.

For complete information, write to Pratt & Whitney Company, Inc., 33 Charter Oak Boulevard, West Hartford, Connecticut.



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It's Not The TOOT That Runs The Train

Frank Sorensen, Jr.

TREASURER, THE CINCINNATI GEAR CO.

Did you ever get a tune lodged in the back of your head, and not be able to get it out? I happened to hear a catchy children's record awhile ago that keeps popping up in my mind; I'm a little fuzzy on the exact details but the gist of the lyrics is that "it's not the toot that runs the train, but the chug chug chug." Even though the song was obviously written to appeal to young children, the simple logic of its message is just as important to us grown-ups. Because it is all too easy to lose track of basic objectives in the normal rush of competitive business and the manufacture of a competitive product. To cut a nickel here or there off the "toot" to meet competition is one thing; but if a dime or two also gets cut off the "chug chug chug" for the same reason, it may *show up* for the first time when the product is in the consumer's hands — with lasting adverse effects. Any such quality lapse in the important O.E. products into which many of our custom gears go would be a serious matter for the manufacturer. Our clients know this, and they know that a gear can be a crucial part in their product — and that's why they come to us. They have found from experience that we make their custom gear costs *inexpensive* by giving them the *quality* and *service* they require. We'll do the same for your firm, if given the opportunity.

THE CINCINNATI GEAR CO.

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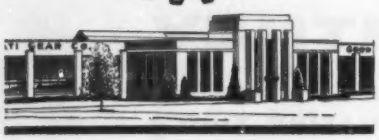


Circle 472 on page 19

New Parts

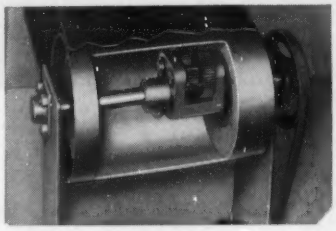
and Signal Corps clinch nut requirements. Locking action is positive. Screw can be inserted from either side of the nut. The fasteners are now available in a range of ferrous and nonferrous materials in sizes down to No. 0. **Nylok Corp.**, 611 Industrial Ave., Paramus, N. J.

Circle 643 on page 19

Gear-Reduction Pulley

is self-contained speed reducer

Newly designed Concentro-drive is a gear reduction unit inside a pulley. The unit is lubricated for life and is made in double and triple reduction types. Input shaft is concentric with the pulley and drives through the dead shaft. Equipment can be narrower in



width and without overhang on drive side. The drive can be used to replace torque arm reducers, geared-head motors and standard reducers. Variable speeds are obtained by mounting motor, equipped with variable-pitch pulley, on sliding base. **Bunke-Musser Inc.**, Dept. 109, Jackson Center, O.

Circle 644 on page 19

Blower Wheel

new design gives high air delivery

Preslock blower wheel operates at a maximum of 1500 rpm against a static pressure of 2 or 3 in. Air delivery can be increased without increasing physical size of the blower. Smooth air flow center-disk design reduces turbulence and increases efficiency. Wide spread between hubs provides lateral stability. Positive mechanical lock secures each blade to center disk. Blades are attached to center disk by four steel fingers individually

MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES

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Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
DeLaval Steam Turbine Co., Trenton, N. J.
Empire Pattern & Foundry Co., Tulsa, Okla.
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundry Co., Chicago, Ill.
The Hamilton Foundry & Machine Co., Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Koehring Co., Milwaukee, Wis.
Lincoln Foundry Corp., Los Angeles, Calif.
Mattison Machine Works, Rockford, Ill.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
The Prescott Co., Menominee, Michigan
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Industries, Inc., Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Valley Iron Works, Inc., St. Paul, Minn.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

SEND FOR FREE BULLETIN 41 TODAY

Meehanite Metal as a Material for Forming & Stamping dies

Write today to Meehanite Metal Corporation, Department 4D, 714 North Avenue, New Rochelle, New York.

MEEHANITE®

Circle 473 on page 19

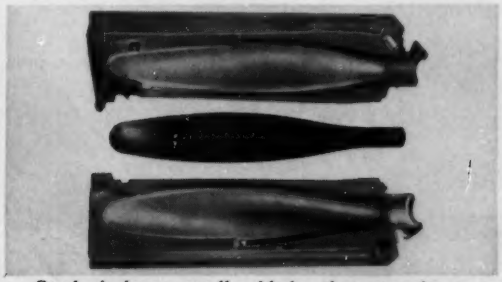
Increase die life and lower production costs with cast-to-form Meehanite metal dies

Longer service life is obtained with Meehanite dies because of their better wear resistance and freedom from galling, scuffing and scoring. Meehanite metal, combining the most desirable properties of gray iron and steel, is one of the most versatile die materials available.

Meehanite dies provide high strength and toughness combined with excellent self-lubricating properties. Dies made in Meehanite metal take on a permanent glass-smooth finish and assure long runs of flawless pressings and shapes. Meehanite dies are used successfully for deep drawing and shaping all steels and non-ferrous alloys.

Substantially lower production costs are achieved by casting large and complicated die parts in one piece rather than building up die assemblies. Machining allowances are held to a minimum and dies may be hardened by local or uniform heat treating without distortion.

For additional information, send for Bulletin No. 41 "Meehanite Metal as a Material for Forming & Stamping Dies."



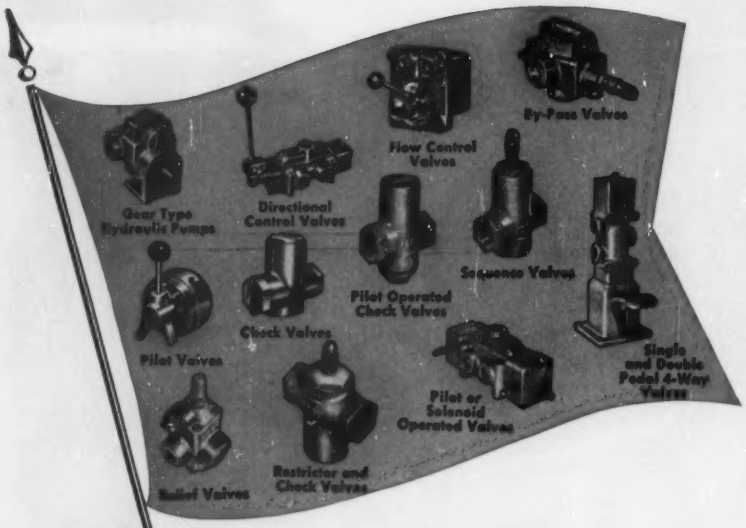
Steel airplane propeller blades that must be as near perfect as possible are manufactured with Meehanite dies that prevent distortion during quenching after heat treating. The dies shown contain cored passages through which cooling water flows.

Meehanite dies have been used in drawing and forming operations for over 25 years by the Ingersoll Products Division of Borg-Warner Corporation in the manufacture of stampings for the automotive, farm equipment and home appliance industries.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK



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Illustrated are but a few of a wide variety of ADEL industrial hydraulic control equipment that offer definite benefits to both the user and builder of machine tools and many other kinds of equipment. ADEL products incorporate proven design and precision construction features that assure dependable operating efficiency over the years. A complete line for every application.

You can simplify your Hydraulic Power Motion Problems by specifying ADEL.

For complete engineering specifications and counsel, Address: ADEL DIVISION, GENERAL METALS CORPORATION 10771 Van Owen Street, Burbank, California

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New Parts

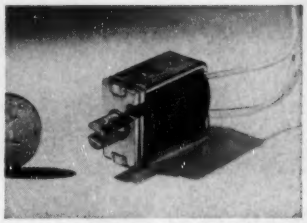
pressed within each blade. Wheel is available in cold rolled steel, stainless steel, rustproof steel or aluminum and is finished in a variety of baked enamels. **Lau Blower Co.**, 2007 Home Ave., Dayton 7, O.

Circle 645 on page 19

Miniature Solenoids

are custom assembled from standard components

Series 100 and 300 solenoids, available in 300 different types, are assembled from 20 standard components. Exact requirements for any custom dc miniature solenoid can be met without lead time re-



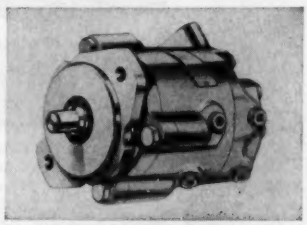
quired for special units. Solenoids feature lightweight, compact design, maximum power-to-size ratio, plungers designed for push or pull, and a wide variety of mountings, coils and wire sizes. Applications are in business machines, automatic process control, automatic machinery and communications. **Joseph Pollak Corp.**, 81 Freeport St., Boston 22, Mass.

Circle 646 on page 19

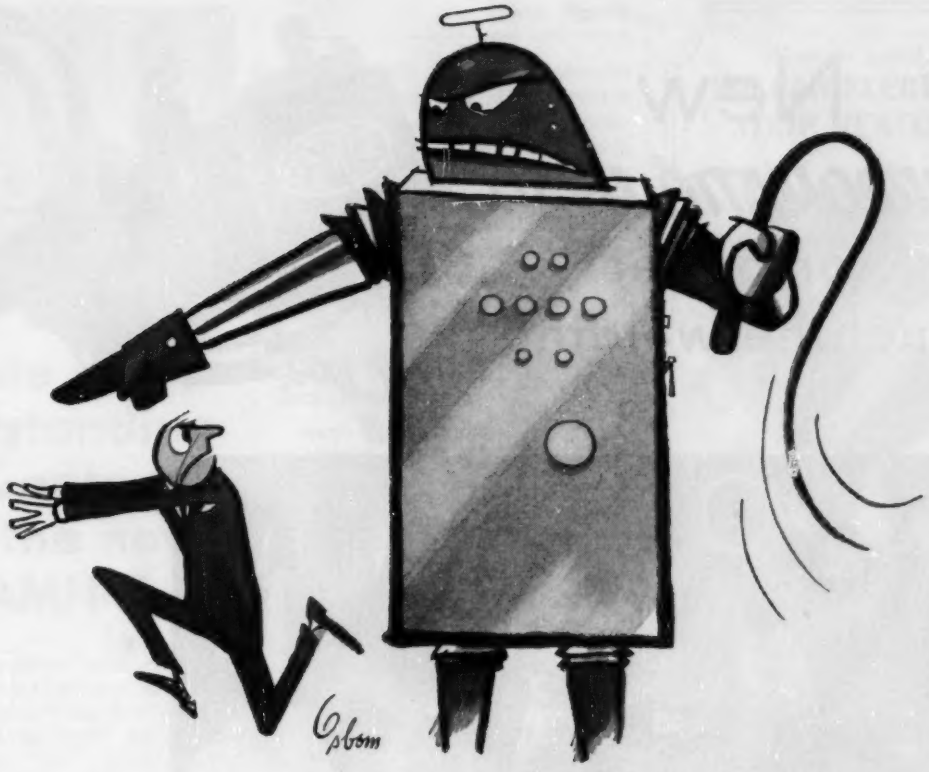
Hydraulic Pump

3000 psi unit delivers 4.15 gpm

Rugged hydraulic piston pump, Series PF-3006, is for construction machinery, materials handling de-



vices, aircraft and agricultural equipment. Pump provides 3000 psi max intermittent pressure and is



Ruled by a Robot?

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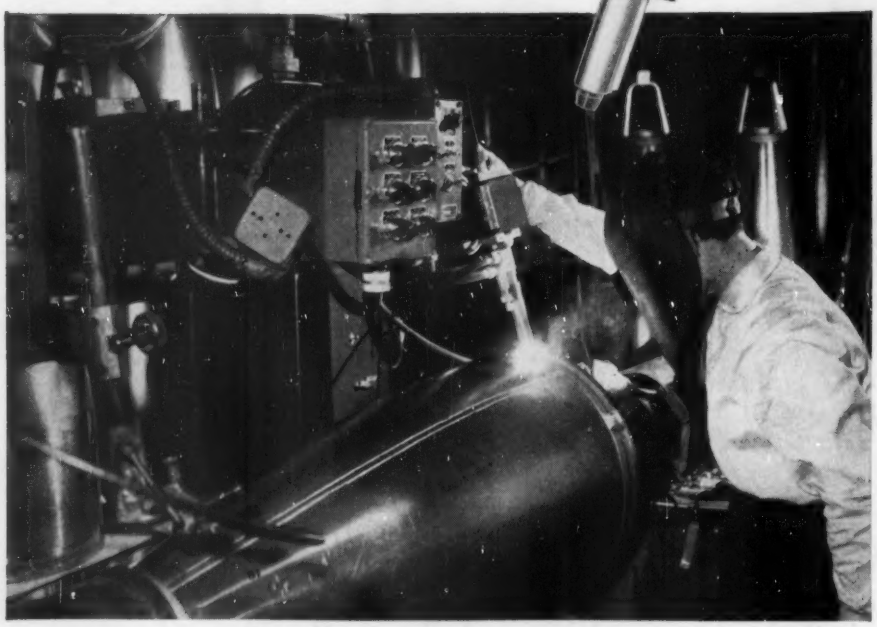
BALL BEARINGS ACTUAL SIZE

are helping to revolutionize the size of robots, machines and precision instruments; making them smaller, lighter, smoother (and kinder!)

*MINIATURE PRECISION BEARINGS, INC.

3 Precision Park, Keene, New Hampshire

New AIRCOMATIC® HEAD for better machine welding



New AMH-B Head welding cylindrical containers on a high production basis. All components of this Aircomatic package — power supply, inert gases, and Aircomatic welding wire — are available from Airco.

The new improved Airco AMH-B Aircomatic Head has been developed for the fabrication of ferrous and nonferrous metals on a high production basis. Used in conjunction with constant arc voltage power supply, this unit provides automatic control of the arc voltage. Standard shielding gases—argon, helium, mixtures (AG75) and CO_2 — are used. Advantages of the AMH-B include: two speed ranges, up to 900 inches per minute high range, and up to 600 inches per minute low range; all types of Aircomatic welding wire, from .030" to 3/32" diameters, can be used.

Wire is fed at a constant speed by an adjustable speed motor. Easy adjustment of the head allows it to be used vertically or horizontally.

For handling most applications the basic package consists of the Aircomatic unit, a machine barrel and a wire guide component kit. The basic Aircomatic unit includes the head, main control panel and remote control operator's station. For complete information write Airco direct.

AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND . . .

AIRCO®

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A division of Air Reduction Company, Incorporated
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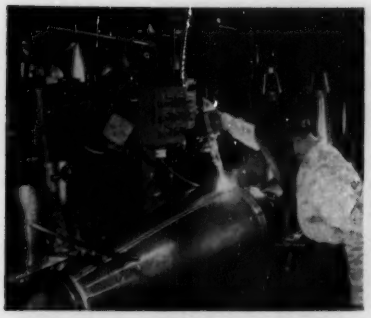
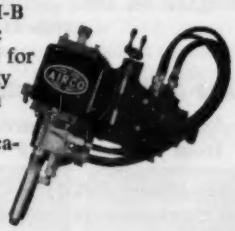
Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetates, alcohols, and other synthetic resins.



Note these outstanding advantages of the new AMH-B

- Accommodates wide range of metal thicknesses — take fine wires (.030") for thin gauges, and up to 3/32" for normal gauges.
- Versatility — through availability of 3 machine barrels with duty ratings of 350, 500 and 600 amperes.
- Extreme compactness contributes to ease of installation, setting up, and servicing.
- Designed so that accessory equipment may be connected easily, quickly.
- Easy to mount: only standard 1½" steel pipe is required.
- Can be used with argon, helium, mixtures (AG 75) and CO_2 gases.
- Simplified design means easier maintenance and longer life.

You'll find the new AMH-B Aircomatic Head ideal for high quality welding on production type applications. For complete details



WRITE DIRECT TO AIRCO

rated at 2000 psi. Displacement is 0.597 cu-in. per revolution; speed is 2600 rpm max; hydraulic horsepower is 8.6 max. Unit weighs 25 lb and will handle 2.8 gpm at 1200 rpm or 4.15 gpm at 1800 rpm. Fitting adapters are available with SAE straight threads or pipe threads. **Dynex Inc.**, 1500 S. Muskego Ave., Milwaukee, Wis.

Circle 647 on page 19

Brakemotors

have torque range from 3 to 345 lb-ft

Cast-iron brakemotors stop instantly and hold heavy loads on all types of equipment. Design incorporates torque range from 3 to 345 lb-ft, one-piece molded friction linings and one-operation torque setting. Load is set and held, in the event of power failure or low voltage, until normal operation is restored. Brakemotors have a

minimum of wearing parts. Adjustments are made easily by removing brake housing and lifting out the operating mechanism. Enclosures are available for outdoor installation or where moist, corrosive, or abrasive dust conditions exist. Standard enclosures include protected, totally enclosed nonventilated, totally enclosed fan-cooled, and explosion-proof. **Reliance Electric & Engineering Co.**, 1088 Ivanhoe Rd., Cleveland 10, O.

Circle 648 on page 19

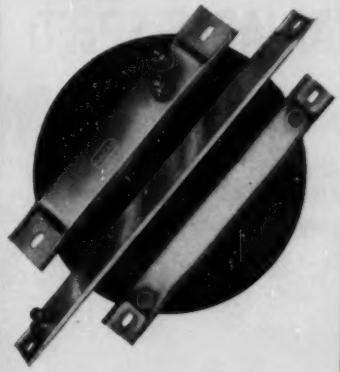
Trimmer Potentiometer

is available in 16 resistance values

Small, lightweight, locking-bushing potentiometer, designated Type 101C, is essentially a locking bushing with a potentiometer built inside. Bushing is stainless steel, mounts in a 5/16-in. hole with a ⅜-in. hexagon mounting nut, and

When to specify

VULCAN ELECTRIC STRIP HEATERS



1. **When application is for:** Contact heating of dies, platens, molds, or any items with flat surfaces to which elements may be clamped. Also air heating source for ovens, air ducts, dryers.
2. **When specifications call for:** Seamless one-piece sheath; rugged non-oxidizing terminal posts; steel sheath for sheath temperatures to 750°F; Chromalloy sheath for sheath temperatures to 1200°F; 8" to 42½" lengths (or longer); 150 to 1500 watts (or higher).
3. **When you have "hot" problems:** Vulcan Engineers are ready to supply special heating units — engineered to your needs.

VULCAN ELECTRIC BAND HEATERS

Constructed basically like the strip heaters, Vulcan Electric Band Heaters are designed for clamping around tanks, pipes, injection heads, etc. Standard width is 1½"; inside diameters from 6" to 15" (special smaller or larger sizes available). Semi or full circular bands. Equipped with mounting tabs or clamping bands.

Write for free catalog.

VULCAN

ELECTRIC COMPANY

DANVERS 6, MASS.

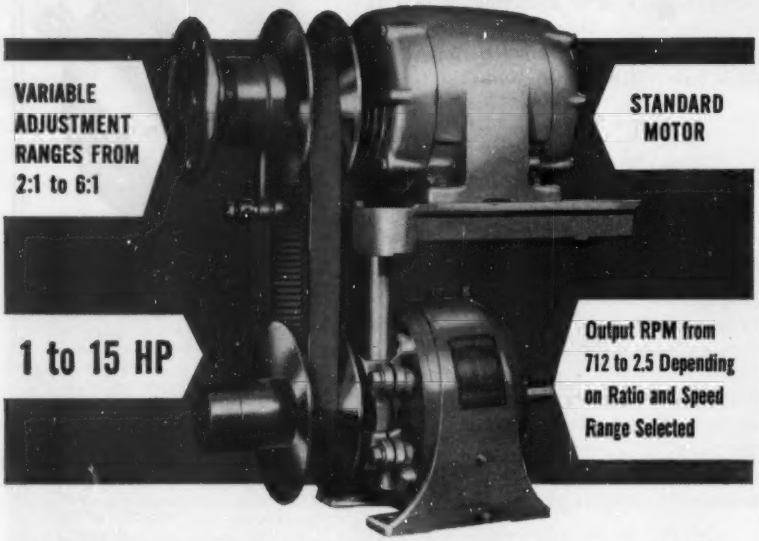
Cartridge • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons Solder and Glue Pots

Circle 477 on page 19

NEW FROM FOOTE BROS.

Vari-Mount

VARIABLE SPEED MOTORIZED DRIVE


VARIABLE ADJUSTMENT RANGES FROM 2:1 to 6:1
STANDARD MOTOR
1 to 15 HP
Output RPM from 712 to 2.5 Depending on Ratio and Speed Range Selected

VARI-MOUNT—the new Variable Speed Motorized Drive offers infinitely variable speed selection, greater flexibility of operation, wide adaptability, easier maintenance and the sound design you expect from Foote Bros.

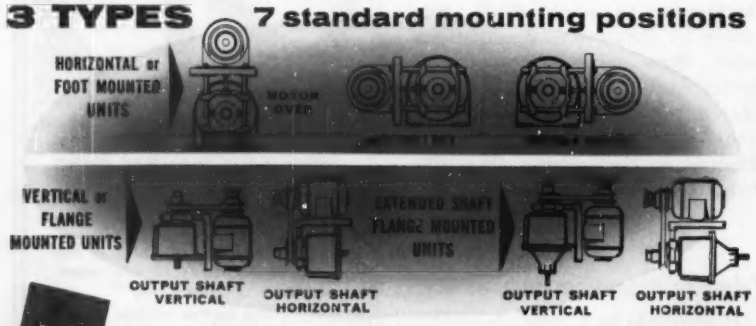
With a Vari-Mount, you can use your own motor—old or new NEMA Standard—or, the unit can be supplied with any standard motor of your choice. The Vari-Mount Reducer incorporates Duti-Rated Lifetime Gearing with file-hard tooth surfaces and tough, ductile cores for maximum life and efficiency.

Positive handwheel control of the adjustable pulley permits pin-point accuracy in speed selection over the entire range. Vari-Mount Units may be equipped with Remote or Automatic speed selection devices if required.

Spring loaded, self-centering Variable Pulley and close-coupled in line design insures permanent belt alignment, smoother performance, and minimum overhung load on motor bearing. No thrust load is imposed on motor bearings at any speed or during speed changes.

Quick belt changes made possible by the wide-open design of the Vari-Mount, together with easily accessible lubrication fittings make maintenance an easy matter.

3 TYPES 7 standard mounting positions



Want complete details?...Write for Vari-Mount Catalog today

this trademark stands for the finest industrial gearing made

T. M. REG. U. S. PAT. OFF.

FOOTE BROS. Duti-Rated LIFETIME GEARING

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Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION

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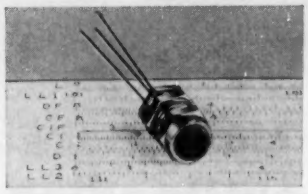
New Parts

is approximately 9/16-in. long. Unit weighs 2.8 grams. It is available in 16 standard resistance values from 47 to 15,000 ohms. Contact resistance is held to a tight tolerance. Power dissipation



is ¼-w up to 95 C, derated to zero at 145 C, for a period of 2000 hr. Small size, light weight, reliability under difficult environment conditions, plus ease of gasketing mounting surfaces, permit use in airborne equipment and in hermetic sealing applications. **Carter Mfg. Corp.**, 23 Washington St., Hudson, Mass.

Circle 649 on page 19

Resin Plastic

has high mechanical and noncorrosive properties

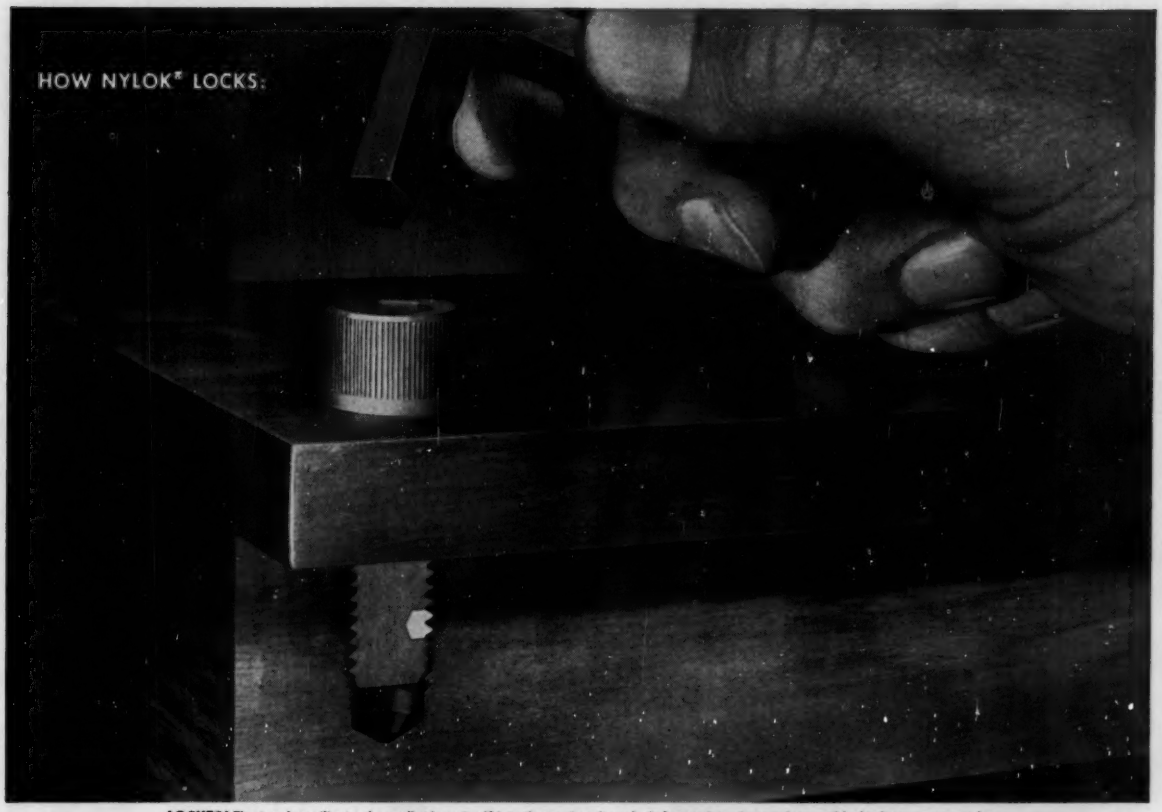
Delrin acetal resin has excellent combination of high tensile strength, toughness, high melting temperature, fatigue life, dimensional stability, solvent resistance and resistance to deformation. Material is suitable for a wide range of applications which require a material able to retain properties under conditions of high temperatures and humidity, during an extended time under stress, or on exposure to most solvents. **E. I. Du Pont de Nemours and Co.**, Wilmington 98, Del.

Circle 650 on page 19

Snap-Acting Thermostat

has fixed temperature settings from −20 to 400 F

Snap-acting, disk-type C7216 Klixon thermostat is designed for applications where maximum shock and vibration resistance are required, such as in aircraft controls and guided missiles, and where space and weight accommodations are limited. Units have fine silver electrical contacts and complete hermetically sealed assembly. Copper-nickel plated steel casing pro-



LOCKED! The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together, and locks the screw securely.

NEW—a complete line of self-locking UNBRAKO socket screw products that won't work loose

They simplify design and save production time

UNBRAKO socket screws are now available embodying the Nylok* self-locking principle. Nylok provides a truly practical new solution to the problem of making screws self-locking.

You save production time when you build products with self-locking UNBRAKOS. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. So are cotter pins and complex multiple set screw installations.

Self-Locking UNBRAKOS are completely reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, on properly seated screws, the pellet acts as a liquid seal.

Self-locking UNBRAKO socket screws come in a complete range of standard sizes and materials. See your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

T.M. Reg. U.S. Pat. Off., The Nylok Corporation

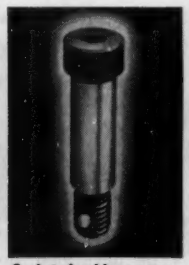
UNBRAKO SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

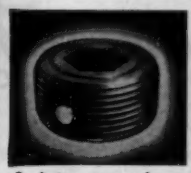
Socket head cap screws. Standard sizes #6 to 1 in.



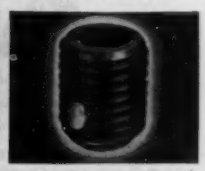
Socket shoulder screws. Standard sizes ¼ to ¾ in.

Flat head socket screws. Standard sizes #6 to ¾ in.

Button head socket screws. #6 to ⅜ in.



Socket pressure plugs. Standard sizes ⅛ to 1¼ in.



Socket set screws. All standard point types. #6 to 1 in.

Non-Contaminating!
Self-Lubricating!
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CARBON PISTON RINGS and ROD PACKINGS

. . . for non-lubricated compressors

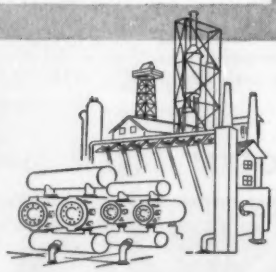
Eliminates lubrication problems in compressors where contamination cannot be tolerated. The inherent lubricating property of Morganite, plus ability to polish and glaze compensating surfaces, assure friction minimizing operation. A corrosion resistant film imparted to opposing metal surfaces prevents scoring . . . reduces maintenance and replacement.

CARBON GLAND RINGS

. . . for high sealing efficiency

These high efficiency pressure and vacuum seals for steam turbines can be safely mounted with less clearance than metallic rings. Unaffected by axial movement of shaft, accommodate considerable radial shaft displacement with no danger of seizure or loss of efficiency.

Specify Morganite! For sealed mechanisms, inaccessible locations or where contamination is a problem — Morganite Self Lubricating Bearings, Valves, Slides, Seal Noses and Pump Vanes are available. Write for complete details and literature, now!



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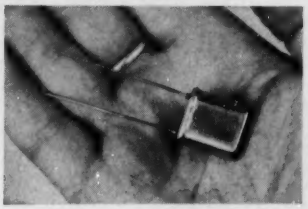
Manufacturers of Fine Carbon Graphite Products including Carbon Specialties, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

New Parts

tects all parts from contamination and moisture. Fixed standard temperature settings range from −20



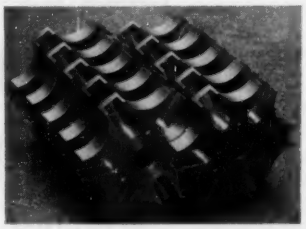
to 400 F. The thermostat is available with No. 20 copper wire leads. **Metals & Controls Corp.,** Spencer Thermostat Div., Attleboro, Mass.

Circle 651 on page 19

Geneva Movements

available in wide range of sizes

Standardized Geneva movements are available with 3, 4, 5, 6 or 8 indexing stations. Any hub, bore, keyway or bearing combination is available. Drives, with any number of points, are available from



½-in. to 20 in. OD. Units are made in two grades: commercial, for adjustable center distances, and precision nonadjustable for use where shafts fit jig-bored housings. Materials are mild steel or heat-treated machinery steel. **Genevamatic Engineering,** 404 E. Ellamae St., Tampa, Fla.

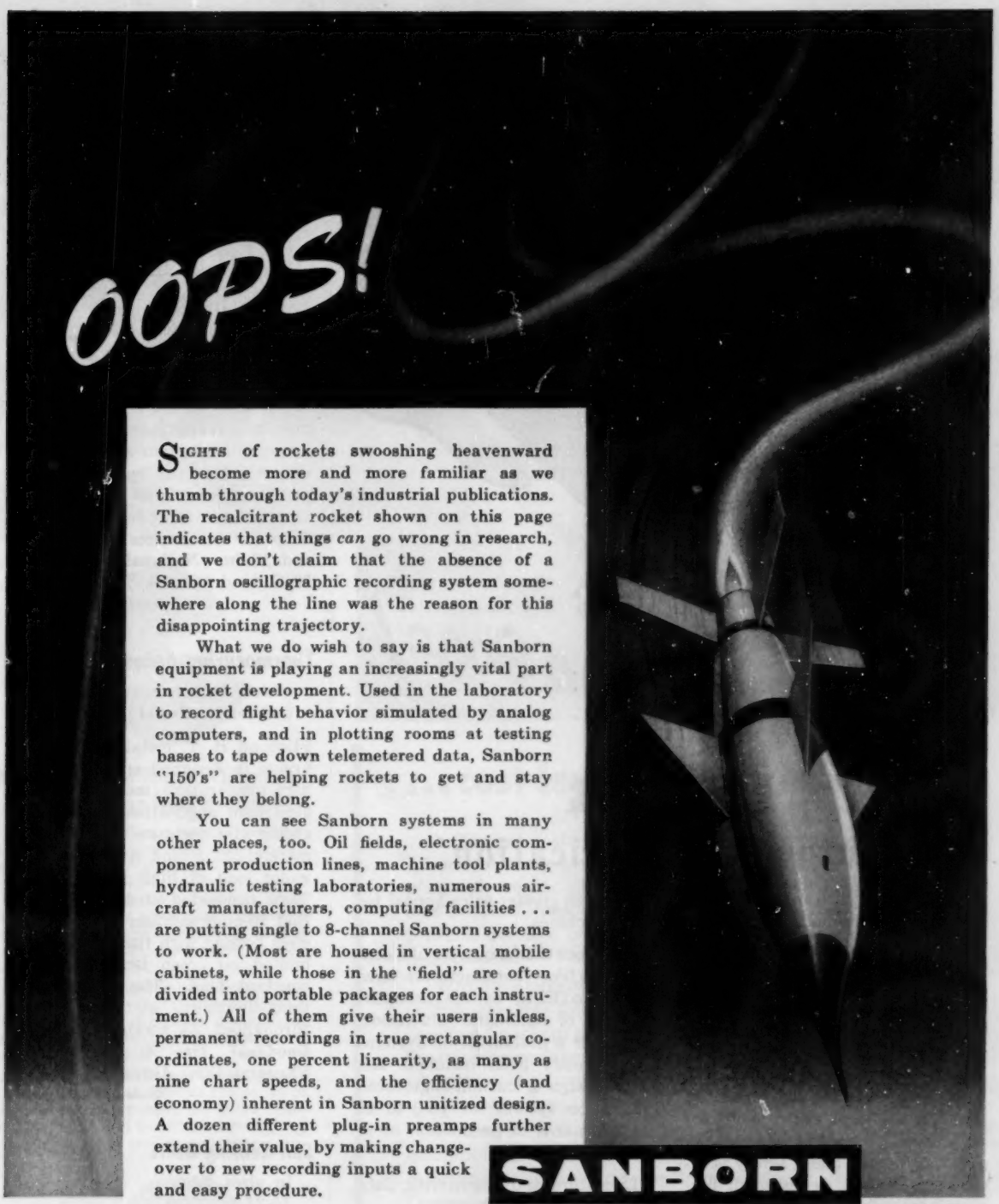
Circle 652 on page 19

Separator

removes moisture from gases

Corrosion-resistant, impingement-type separator for removal of liquid particles from air and other gases is a compact self-contained unit ready for installation in pipe line. Graphite rods are staggered in rows within cylinder. As gas to be scrubbed flows through cylinder, moisture particles impinge on

Circle 480 on page 19

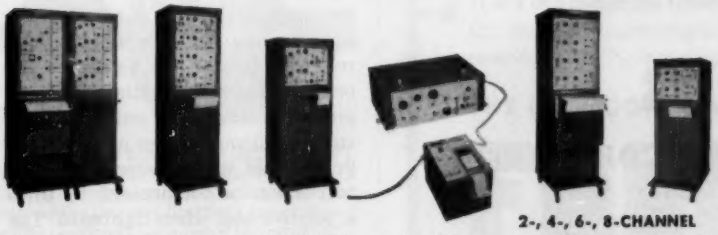


SIGHTS of rockets swooshing heavenward become more and more familiar as we thumb through today's industrial publications. The recalcitrant rocket shown on this page indicates that things *can* go wrong in research, and we don't claim that the absence of a Sanborn oscillographic recording system somewhere along the line was the reason for this disappointing trajectory.

What we do wish to say is that Sanborn equipment is playing an increasingly vital part in rocket development. Used in the laboratory to record flight behavior simulated by analog computers, and in plotting rooms at testing bases to tape down telemetered data, Sanborn "150's" are helping rockets to get and stay where they belong.

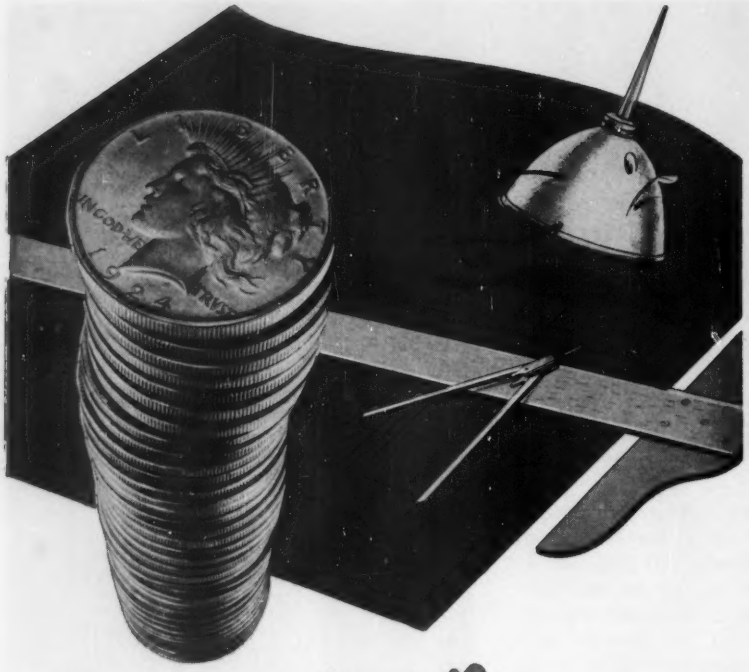
You can see Sanborn systems in many other places, too. Oil fields, electronic component production lines, machine tool plants, hydraulic testing laboratories, numerous aircraft manufacturers, computing facilities . . . are putting single to 8-channel Sanborn systems to work. (Most are housed in vertical mobile cabinets, while those in the "field" are often divided into portable packages for each instrument.) All of them give their users inkless, permanent recordings in true rectangular coordinates, one percent linearity, as many as nine chart speeds, and the efficiency (and economy) inherent in Sanborn unitized design. A dozen different plug-in preamps further extend their value, by making changeover to new recording inputs a quick and easy procedure.

SANBORN COMPANY
CAMBRIDGE 39, MASSACHUSETTS



8-, 6-CHANNEL 4-CHANNEL 2-CHANNEL 1-CHANNEL 2-, 4-, 6-, 8-CHANNEL ANALOG COMPUTER SYSTEMS

Which way rockets are going may not be a primary concern of yours. But if recording problems are, you're apt to find some interesting and useful answers in Sanborn's 16 page "150 System" catalog. Write to us for a copy.



Profit Grows When The Oil Can Goes!

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Automatic Lubrication

When you design a machine to include Bijur Automatic Lubrication as an integral component, the user profits many ways. Costly hand oiling is eliminated. Repair bills are substantially reduced. Productive capacity is increased because machines are lubricated while in operation; downtime is reduced. Every bearing receives the right quantity of oil at the right time. There are no starved or flooded bearings. In your customer's plant, safety is increased; fire risk is lessened; personnel injuries are avoided. All this adds up to greater sales appeal for your machines.

For more than a quarter of a century, machine manufacturers have looked to Bijur as the accepted standard of automatic lubrication. Well over a million Bijur Systems have already been installed. Let Bijur design a custom-engineered lubrication system for you, to fit machines now in production or in the planning stage.

Literature and engineering data are yours for the asking.

B-1 2368

BIJUR

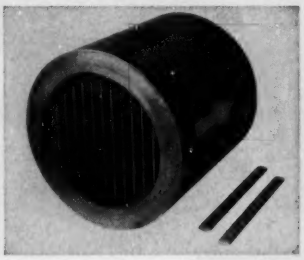
LUBRICATING CORPORATION

Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

New Parts

the separator rods. At pressure of 1 atm, scrubber is designed for gas approach velocity of 30 fps; pressure drop is under 1 in. water. Graphite materials are chemically



inert to mineral acids, organic solvents, salt solutions and other corrosives. Unit can operate at temperatures from −40 to 340 F and at pressures from full vacuum to 65 psig. Stock sizes are 6, 8, 12, and 16 in. **National Carbon Co.**, 30 E. 42nd St., New York 17, N. Y.

Circle 653 on page 19

Thermocuring Adhesive

resists high temperatures and retains flexibility

Pliobond H. T. metal-to-metal adhesive is designed specifically for high-temperature mechanical and electronic applications. It has a curing temperature of approximately 350 F and does not creep under load at high temperatures. Tests conducted at 400 F showed that 40-gage samples of cold-rolled steel bonded with the adhesive exhibited no creep tendency under constant load. The material retains flexibility at temperatures throughout its serviceable range. **Goodyear Tire & Rubber Co.**, Chemical Div., Akron 16, Ohio.

Circle 654 on page 19

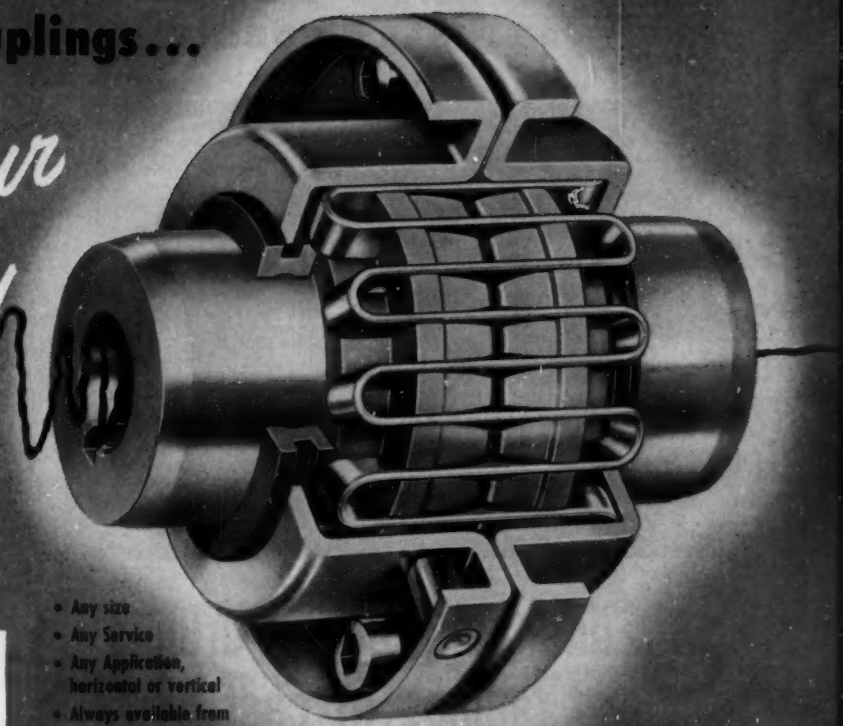
Self-Sealing Bolts

in sizes from 10-32 to ½-20

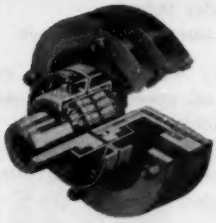
Seelbolts are useful for high-pressure sealing and for applications requiring resistance to heavy vibration. They are available as one-piece, preassembled units. An O-ring of silicone rubber or neoprene, firmly held in a groove under the bolt head, is compressed to form a positive seal when tightened. The bolts conform to the dimensions

Falk Steelflex Couplings...

Protect your machinery in 2 ways



- Any size
- Any Service
- Any Application, horizontal or vertical
- Always available from factory, field or distributor stocks

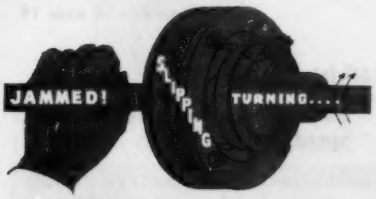


Falk Controlled Torque Couplings prevent damage from overloads

In applications where danger from overloads exists, use the FALK Type FT Controlled Torque Coupling. The Type FT has all the features and advantages of standard FALK Steelflex couplings—and, in addition, has an adjustable friction slip clutch, enabling the operator to set the coupling to slip at any predetermined overload.

This controlled-torque principle not only prevents transmission of dangerous shocks and limits overloads; it eliminates the breaking of shafts caused by jamming of driven equipment.

An outstanding advantage of the Type FT Coupling is that, as soon as the cause of the overload is removed, the entire coupling will rotate and transmit power without replacing parts or repairing coupling.



There's real economy in using Type FT Controlled Torque Couplings. Many users have reported that these couplings paid for themselves the very first time they slipped (under overload) because of the protection against damaged driving or driven machinery!

...cost less per year of service!

You get *double protection* when you connect your driving and driven machinery with a Falk Steelflex Coupling—the all-steel coupling with the exclusive grid-groove design! First, its *torsional resilience* smothers shock and vibration; and second, the Steelflex design prevents damage and lowered efficiency by accommodating shaft misalignment.

Why have increasing numbers of key men in industry standardized on Falk Steelflex Couplings? Their experience has proved that Falk Steelflex Couplings prolong the service life of their machinery... are trouble-free and need minimum maintenance... are easy to install, lubricate and disconnect... and *cost less per year of service* than ordinary couplings.

One basic Steelflex design—the type F, in its many sizes—is adaptable to more than 90% of all industrial applications. For applications involving danger from overloads, Modified Type FT Controlled Torque couplings (see column at left) are ideally suited. There are numerous other special or dual purpose Steelflex couplings for unusual applications. **Write to Department 247** for engineering bulletin, including selection and dimension tables.

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

FALK

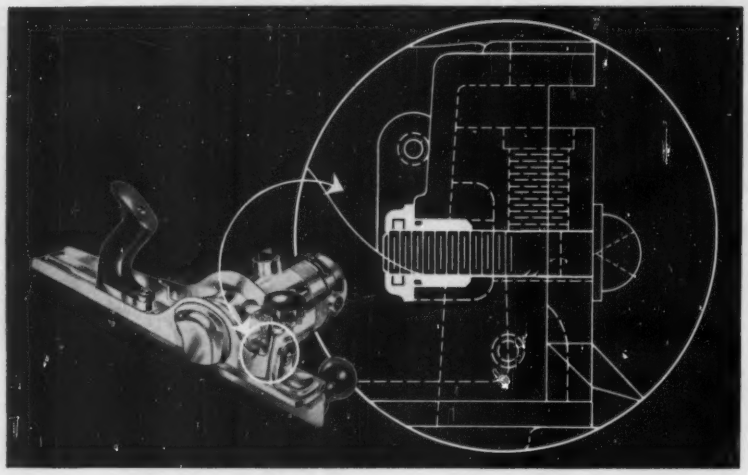
...a good name in industry

MANUFACTURERS OF:

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

Circle 483 on page 19

FASTENER PROBLEM



Eliminating double-drilling and tapping of cast parts

On the Stanley Power Plane, a screw is used to provide clamping and adjustment for depth of cut. Threads to receive this locking screw are in a relatively inaccessible section of the casting. A tapping operation in assembly would be slow and costly.

An ESNA Spline type nut solves this problem. It is simply pressed into a cored hole in the casting. No hole preparation or tapping is necessary and substantial savings in production costs result.

The Spline type Elastic Stop® nut has a straight knurled cylindrical shank as an extension of the main body of the nut. Pressed into a soft metal casting, the splines serve as a broach to make the nut self-retaining. The red ESNA locking collar provides a positive lock for the adjusting screw. It permits precise adjustment that won't be disturbed by vibration or jolting . . . particularly important in maintaining adjustment in applications like this. And it can be re-used many times.

Whatever your fastening problem, it will pay you to find out how ESNA can help you solve it.

MAIL COUPON FOR DESIGN INFORMATION

ESNA®

Dept. N2-14, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey
Please send me the following fastening information:

☐ Bulletin on Spline type Elastic Stop nut.

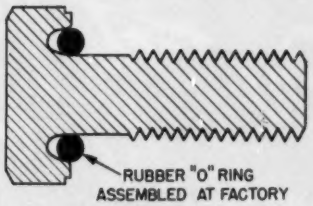
☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____
Firm_____
Street_____
City_____ Zone____ State_____

Circle 484 on page 19

New Parts

and materials of AN bolts. They are available with standard hexagonal heads in sizes from 10-32



to ½-20. Supplied in steel, brass, corrosion-resistant steel or aluminum, they can be plated in any desired finish. **Automatic & Precision Mfg. Co.**, 252 Hawthorne Ave., Yonkers, N. Y.

Circle 655 on page 19

Stepless Speed Reducer

provides infinite adjustment within range

Infinitely variable speed reducer offers fast speed changes and simple remote control set-ups. Lever control permits changing of output speed while unit is operating or stopped. Output shaft can be

stopped without stopping power source. Control lever requires small force to reposition, allowing simple remote controls. Lever has 40 degree movement and large quadrant for easy calibration. Speed is repeated accurately and lever may be locked with thumb screw. **Reveo Inc.**, 1900 Lyndale Ave. S, Minneapolis, Minn.

Circle 656 on page 19

Multi-contact Relay

miniature dc unit offers speed and reliability

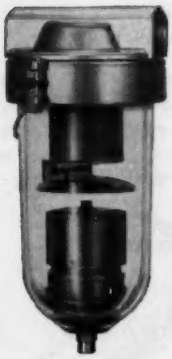
Miniature telephone-type multicontact relay is only 1 5/32 long by 23/32-in. wide. Height is dependent upon number of springs. Unit is also available hermetically sealed with overall size of 2⅛ by

Good News Norgren

for design engineers and PLANT ENGINEERS

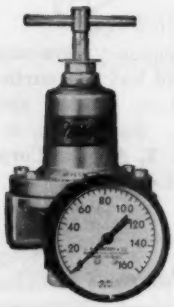
ANNOUNCES

Important New Developments in Compressed Air Filters and Pressure Regulators



NEW Norgren Air Line Filters

- **LESS PRESSURE DROP** — larger passages and larger filter element.
- **BETTER LIQUID REMOVAL** — Improved louver plate and baffle design. Removes more liquid from the compressed air line.
- **CHOICE OF FILTER ELEMENT**—interchangeable filter elements, 74, 64, or 25 micron.



NEW Norgren Pressure Regulators

- **GREATER ACCURACY OF REGULATED PRESSURE** — balanced valve and increased effective diaphragm area provide improved accuracy over a wide operating range.
- **RELIEVING OR NON-RELIEVING TYPE AVAILABLE**
- **IMPROVED RELIEVING CHARACTERISTICS** — automatic relief of excess pressure. Holds system pressure close to regulator setting.

For complete information...

call your nearby Norgren Representative listed in your telephone directory—or

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3442 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

Acme SPECIAL ATTACHMENTS

provide great versatility for CONVEYOR CHAINS

Acme Precision conveyor chains are easily adapted to special requirements by the use of stock or specially designed attachments. Possibilities for modification of Acme standard chains are practically endless. In all adaptations, Acme engineers are skilled in retaining as many standard parts as possible to reduce costs.

Most attachments are in reality special plates which take the place of standard chain plate and are stamped from dies in production quantities. Attachments in smaller lots can be hand machined, cast, bent or welded to your specifications.

Whether you use a simple extended pin design or more elaborate attachments used for timing and motioning special conveyor lines, Acme engineers are ready to design practical applications for you.

All Acme conveyor attachments available in stainless steel for the packaging and food industries. Write our engineering department.

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Write Dept. 6-H for your 80-page copy of Acme's latest catalog. Packed with valuable chain data. An indispensable chain reference.

Call ACME for Service

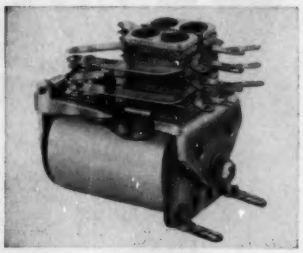
Acme Chain Corporation

HOLYOKE MASSACHUSETTS

Circle 486 on page 19

New Parts

1⅝ by 1 in. Coil is dc only, single or double wound. Resistance is up to 14,000 ohms. Maximum power dissipation is 3 w. Phosphor bronze contacts are A, B, C or D



form and are available in wide range of materials. Up to 18 springs are available in the relay, which combines speed, reliability and high resistance to shock and vibration in a miniature unit. **Phillips Control Corp.,** 59 W. Washington St., Joliet, Ill.

Circle 657 on page 19

Cushion Clamp

absorbs vibration and dissipates heat

Stainless-steel cushion clamp resists temperatures to 1500 F. Both clamp and cushion are type 321 stainless steel. Cushion is corrugated to furnish spring action

for high-frequency, low-amplitude vibration and has flat surfaces for maximum tube contact and heat dissipation. Size range is ¼-in. to 3 in. ID. **T. A. Mfg. Corp.,** 4607 Alger St., Los Angeles 39, Calif.

Circle 658 on page 19

Solenoid Valve

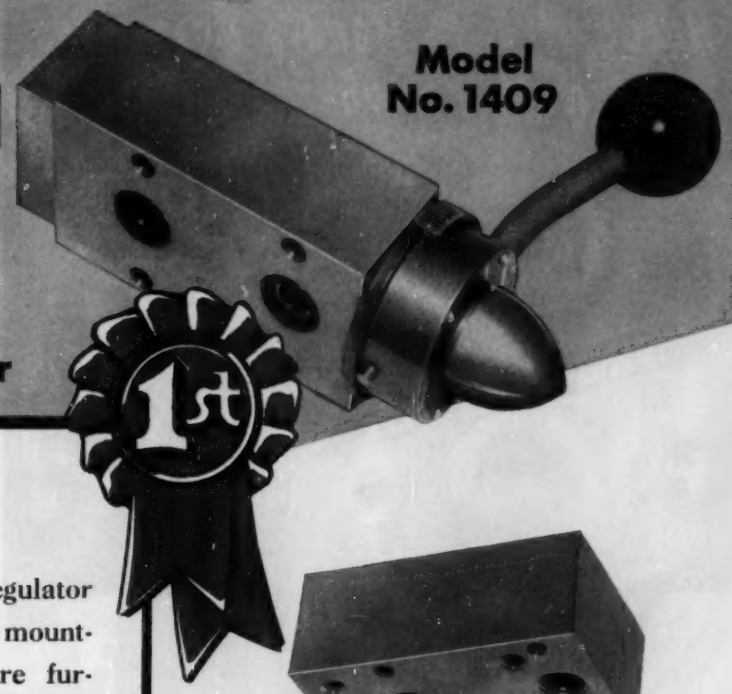
floating diaphragm gives unimpeded fluid flow

Synthetic diaphragm in solenoid valve floats freely, providing high fluid flow. Unit is pilot operated with no metal-to-metal contacts to wear. It is adaptable for control of water, air, brine, light oils, in-

Another WATERMAN WINNER

Model No. 1409

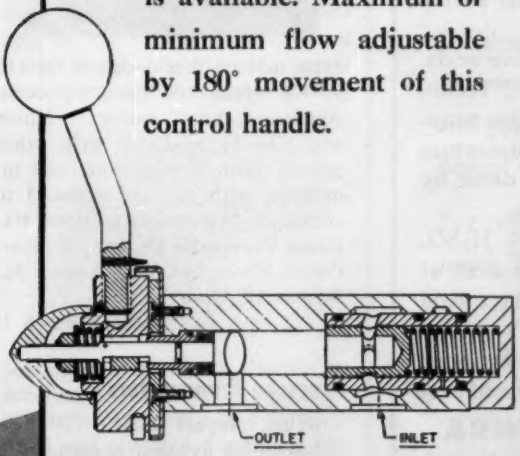
Adjustable Flow Regulator

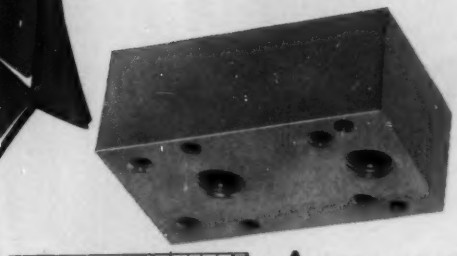


An adjustable flow regulator adapted for manifold mounting. Sub-plate kits are furnished with built-in check valves for free reverse flow.

They are interchangeable, dependable, lightweight and easily installed.

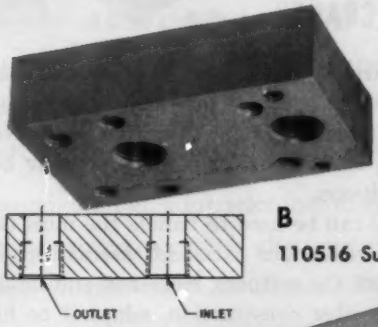
Either right or left hand rotation of control handle is available. Maximum or minimum flow adjustable by 180° movement of this control handle.





A

110534 Sub-Plate Kit with built-in check valve for free reverse flow.



B

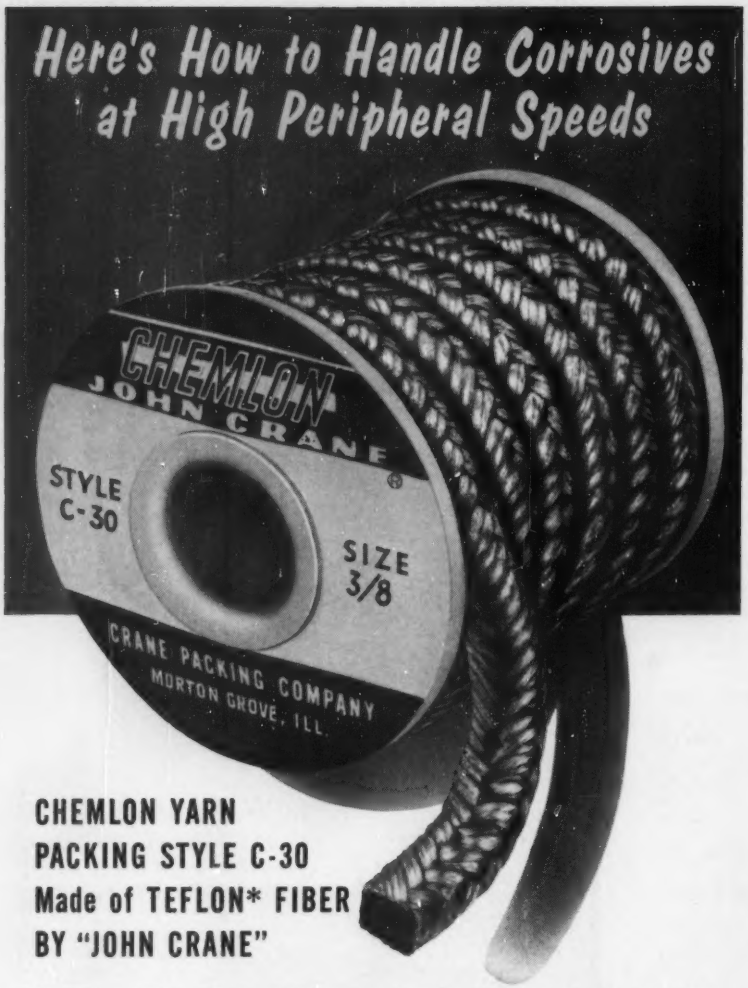
110516 Sub-Plate Kit.

Write for illustrated bulletin F describing the many valuable features of this Adjustable Flow Regulator.

WATERMAN ENGINEERING COMPANY

725 CUSTER AVENUE • EVANSTON, ILLINOIS

Here's How to Handle Corrosives at High Peripheral Speeds



CHEMLON YARN PACKING STYLE C-30 Made of TEFLON* FIBER BY "JOHN CRANE"

Chemlon Yarn Style C-30 extra tough packing gives you two important advantages not provided by other types of braided or molded Teflon packing: 1) positive sealing efficiency at high peripheral speeds; 2) cooler running stuffing box under severe service conditions.

Style C-30 can be used to handle the most destructive acids, alkalis or solvents. The excellent thermal properties of Teflon, combined with the softness, resiliency and fluid retentive properties of fine fiber construction, adapt it to high temperature conditions to +300°F. The packing is made firm and dense by means of a special process which eliminates *large* voids.

HERE'S PERFORMANCE PROOF:—Fluid handled: 45% H_2SO_4 (impure) at 170°F.—Operating conditions: 1¼" pump shaft at 1700 rpm. or 555 fpm. peripheral speed. Results: 46 days good service. Previous best service record 7 to 10 days.

Chemlon Yarn Packing Style C-30 is available in spool or coil form, in a wide range of sizes from ⅛" up. *Can be lubricated with Teflon suspensoid or various types of lubricants.*

Send for Bulletin No. P-321. Crane Packing Co., 6425 Oakton Street, Morton Grove, Ill. (Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

*DuPont Trademark

JOHN CRANE **CRANE PACKING COMPANY** 38 YEARS INDUSTRIAL PROGRESS

OFFICES IN ALL PRINCIPAL CITIES

New Parts

dustrial gas, Freon 12 and 22, and other noncorrosive fluids from 0 to 225 F. Valve will operate on pres-

sure differentials between 1 and 250 psi. **Jackes-Evans Mfg. Co.,** Controls Div., 4427 Geraldine Ave., St. Louis 15, Mo.

Circle 659 on page 19

Gear Motor

for airborne strip-chart recorders

This 400-cycle hysteresis synchronous gear motor is designed for airborne strip-chart recorders and other applications. Physically interchangeable with RBC-2505 60-

cycle motors, it is designed for 115 v, 400 cycle, 100 rpm, 7.5 oz-in. continuous-duty rating. Motor will also be available with other speeds, both synchronous and induction, with ratings adjusted to corresponding gear reductions. **National Pneumatic Co. Inc.,** Holtzer-Cabot Motor Div., 125 Amory St., Boston 19, Mass.

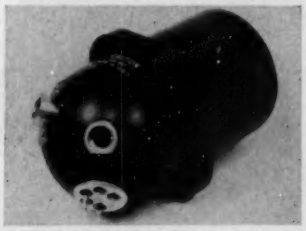
Circle 660 on page 19

Pressure Transmitters

light, compact units have high dynamic accuracy

Synchrotel pressure transmitters, used in high-speed aircraft and guided missiles for transducing pressure values as electrical sig-

nals, are light, compact and have less internal static volume than previous models. Units are designed for use wherever accurate measurement of differential or absolute pressure functions are mandatory, and where space and weight are critical factors. Design permits increased application to



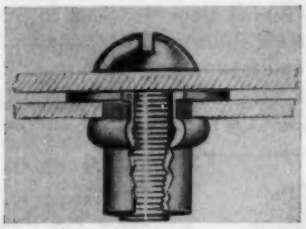
problems of ultrasonic speeds and high altitudes. Total weight of the transmitters, enclosed in lightweight sheet metal cases, is 1 lb. Diminished internal static volume, more precise calibration, and better temperature compensation provide high dynamic accuracy. **Kollsman Instrument Corp.**, 80-08 45th Ave., Elmhurst 73, N. Y.

Circle 661 on page 19

Self-Locking Fastener

blind-hole unit is vibration proof

Nylon, self-locking, self-retaining fastening device provides positive fastening in blind spots. Unit joins two surfaces securely and provides strong threads in sheet metal. Device is nonthreaded Nylon nut that snaps into a square hole in inner surface of material being joined. Self-tapping screw driven into device engages mating



portion and impresses threads on inner wall. As screw is tightened, counterbored section is drawn upward and outward, forming a rigid collar behind the lower side of inner piece of metal, locking parts together. Constant grip of Nylon on threads of screw creates vibra-

ARWOOD Investment Casting may be the answer to your design problems when ferrous or nonferrous parts or components must be of intricate shape and unusual contour, of metals difficult or impossible to machine.

Problems like configuration, alloy selection, tolerances, surface finish and inspection standards affect production cost and performance. Choose wisely . . . Choose ARWOOD for design assistance and production efficiency.

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"PIONEERS IN INVESTMENT CASTING"

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NO WAITING!

TAPER-LOCK SPROCKETS
SINGLE AND DOUBLE STRAND!

NOW Taper-Lock *Double* Strand Sprockets are available—from stock—ready for the shaft without re-machining!

They offer all the advantages of Taper-Lock mounting. Easy on! Easy off! Precision machined at the factory, they come to you with accurate, concentric bores —insuring full contact between hub and shaft. Taper-Lock grips with the firmness of a shrunk-on fit!

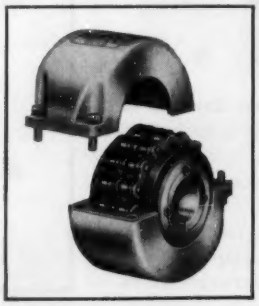
There is no flange, no collar, no protruding part. Flush design means *safety*... If the sprocket becomes worn, you replace only the tooth part. The bushing is used again and again. And Taper-Lock bushings are interchangeable in Dodge Taper-Lock Sheaves, Couplings and Conveyor Pulleys!

Taper-Lock Sprockets and Dodge Roller Chain (made to ASA standards) are stocked by Dodge distributors. Single Strand sizes range from No. 40 to No. 160, up to 112 teeth; Double Strand from No. 40-2 to 80-2, up to 102 teeth. Write for Bulletin A-644 containing selection, installation and maintenance data.

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new methods. Look for his name under "Power Transmission Machinery" in your classified phone book, or write us.



TAPER-LOCK CHAIN COUPLINGS

Accommodates common minor shaft misalignments. Provides strong, compact coupling. Available with covers, for appearance, safety, dirt protection and lubrication — which increases coupling life.

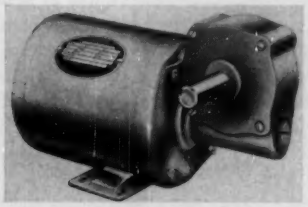
tion and shock-resistant assembly. **Tru-Lok Fasteners Inc.**, Woodbury, Conn.

Circle 662 on page 19

Gearmotor

adjustable torque unit delivers up to 1000 lb-in.

Gearmotor has full starting torque and adjustable running torque. Unit is adaptable for valve operating equipment, measuring devices, and other applications. Output



torque is adjustable from 0 to 1000 lb-in. at 100 rpm. Motor can be made to cut out at any predetermined overload. **Brown-Brockmeyer Co.**, Dayton 1, Ohio.

Circle 663 on page 19

Panel Meter

has extreme sensitivity

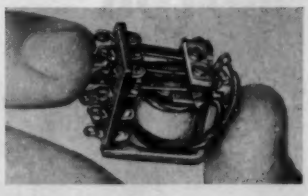
Combining extreme sensitivity with unusual shock resistance, panel meter has full scale range of 0 to 20 mu amp, yet withstands over 1200 ft-lb military shock test. Meter is completely sealed from front; molded-rubber base provides chock mounting and adequate sealing at rear. **Assembly Products Inc.**, Wilson Mills Rd, Chesterland, O.

Circle 664 on page 19

Subminiature Relay

has high shock and vibration resistance

Subminiature 3-pole relay occupies less than 1 cu in. of space. Designated the KM, the relay is engineered for miniaturization and multiplicity of action for such products as small business machines, alarm systems, automated toys, remote controls and intercom systems. Voltage range is up to 48 v dc nominal with pull-in at



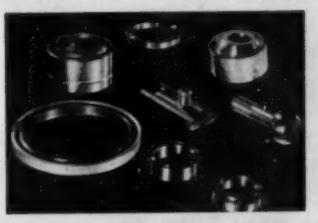
75 per cent of nominal. Coil has 1 w power requirement and resistances to 6700 ohms. Temperature range is −45 to 55 C; shock resistance is 30 *g;* vibration resistance is 5 *g* in range from 10 to 55 cps. Dimensions are 1⅛ in. wide x 17/32-in. wide x 15/16-in. high. **Potter and Brumfield Inc.**, Princeton, Ind.

Circle 665 on page 19

Special Bearings

designed to meet customer's requirements

Custom-designed and manufactured antifriction bearings meet special requirements such as high temperature, corrosion resistance, nonmagnetic properties or special configurations. Bearings are also manufactured to conduct or insulate electrical current. Units may



be extreme-precision type, low-torque, air or oil seal, high-load thin-wall, or self-aligning double-row types. Other varieties include linear bearings, thrust bearings, high-speed bearings, and shock-resistant bearings. **Industrial Tectonics, Inc.**, 3684 Jackson Rd., Ann Arbor, Mich.

Circle 666 on page 19

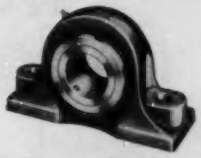
High-Pressure Seal

for banjo fittings at pressures to 5000 psi

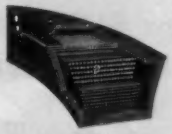
Seal assures zero leakage of air, oil or fuel from banjo fitting at pressures to 5000 psi. Temperature range is −65 to 350 F, or 500 F intermittent. Seal eliminates crush

DODGE PRODUCTS you should know

TAPER-LOCK
ALL-STEEL
CONVEYOR PULLEYS



SC and SCM
BALL BEARING
PILLOW BLOCKS



SEALED-LIFE V-BELTS

DODGE BULLETINS YOU SHOULD HAVE

1 TAPER-LOCK STEEL CONVEYOR PULLEYS. Construction details, sizes, dimensions. Bulletin D54.

1 ROLLING BEARINGS. Load ratings, dimensions and other data on Dodge-Timken and SC and SCM Ball Bearings. Bulletin A638.

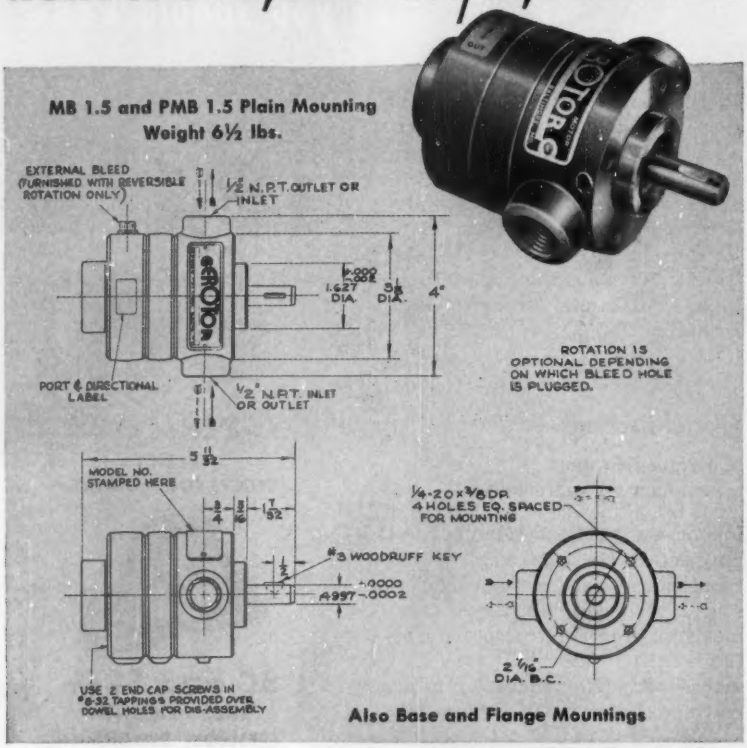
1 SEALED-LIFE V-BELTS. Construction details and data on sizes, pitch lengths and outside lengths. Bulletin A-606.

Write for your copies.
DODGE MANUFACTURING CORPORATION
3300 Union Street • Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

Circle 491 on page 19

Hydraulic PUMP-MOTOR delivers 2,000 P.S.I./5,000 R.P.M.


MB 1.5 and PMB 1.5 Plain Mounting
Weight 6½ lbs.
EXTERNAL BLEED (FURNISHED WITH REVERSIBLE ROTATION ONLY)
½" N.P.T. OUTLET OR INLET
GEROTOR
1.627 DIA.
4"
PORT & DIRECTIONAL LABEL
½" N.P.T. INLET OR OUTLET
ROTATION IS OPTIONAL DEPENDING ON WHICH BLEED HOLE IS PLUGGED.
MODEL NO. STAMPED HERE
#3 WOODRUFF KEY
.4997 +.0000 -.0002
⅛-20 x ⅜ DP 4 HOLES EQ. SPACED FOR MOUNTING
2 7/16" DIA. B.C.
USE 2 END CAP SCREWS IN #8-32 TAPPINGS PROVIDED OVER DOWEL HOLES FOR DIS-ASSEMBLY
Also Base and Flange Mountings

New GEROTOR MB-PMB 1.5 PUMP-MOTOR opens wider horizons to the hydraulic designer

Usable as pump or motor, this compact power package delivers—

- 2,000 P.S.I.—5,000 R.P.M.
- 115% Starting Torque
- 10:1 Speed Range, at
- Constant Torque
- Reversibility
- Up to 3.4 H.P.
- High Efficiency, at
- Low Operating Cost

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Progress Through Fluid Power by—

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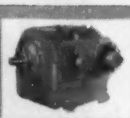
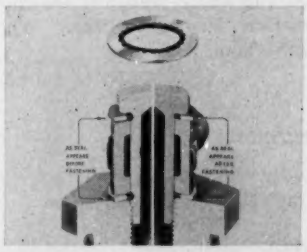
Hydraulic Pumps and Motors


Variable Speed Hydraulic Transmissions

PneuBin—Pneumatic Bin Evacuators

New Parts



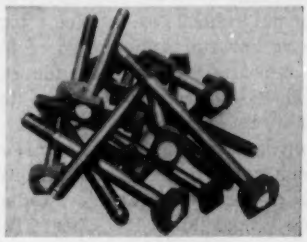
washers, provides metal-to-metal contact of faying surfaces and assures no loss of seal due to cold flow, reverses or surges. Seal is reusable. Unit allows use of space-saving banjo fitting without maintenance difficulties or leakage at boss and bolt head ends of fitting. **Franklin C. Wolfe Co., Inc.,** 10567 Jefferson Blvd., Culver City, Calif.

Circle 667 on page 19

T-Slot Bolts

forged units have high tensile strength

Forged T and T-slot bolts are two to three times as strong as ordinary bolts. Made of aircraft-quality alloy steel, bolts are heat treated to provide tensile strength of 150,000 psi min. Forging technique provides maximum strength at critical stress points. Bolts heads



are extra long for maximum bearing. Finish is black penetrate. JIC standard bolts are available in lengths from 2 in. up. **Jergens Tool Specialty Co.,** 712 E. 163rd St., Cleveland 10, O.

Circle 668 on page 19

Small Motors

can be mounted at any angle

Small, lightweight capacitor-start and split-phase motors are available with rigid or resilient base in NEMA 48 frame sizes. Lubrication system permits mounting sleeve

Circle 492 on page 19

Circle 493 on page 19→

17

....for better FORGING PRODUCTION!

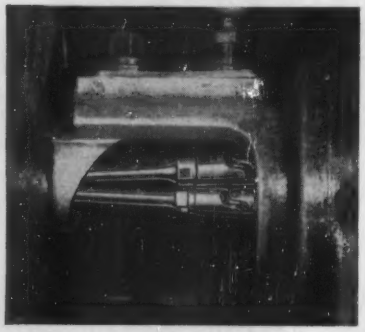
Sharon Open Hearth Quality Forging Ingots — now available in Carbon and Alloy grades, with ingot weights up to 109,000 pounds. Sharon Electric Furnace Quality Ingots — Stainless and Alloy grades, up to 50,000 pounds. • Sharon is also a prime supplier of billets, blooms and slabs — to customer specifications — in Stainless and Alloy grades. For prices — contact the Sharon Steel Corporation, Forging and Semi-Finished Steel Sales Department — or one of the district sales offices listed below.

SHARONSTEEL

SHARON STEEL CORPORATION *Sharon, Pennsylvania*

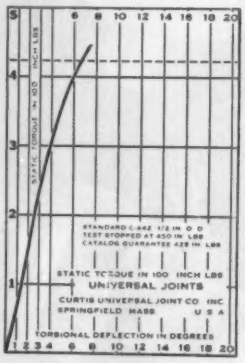
DISTRICT SALES OFFICES: Chicago, Cincinnati, Cleveland, Dayton, Detroit, Grand Rapids, Indianapolis, Los Angeles, Milwaukee, New York, Philadelphia, Rochester, San Francisco, Sharon, Seattle, Montreal, Que., Toronto, Ont.

Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.


STATIC TORQUE IN 100 INCH LBS
STANDARD C-662 1/2 IN O D
TEST STOPPED AT 450 IN LBS
CATALOG GUARANTEE 428 IN LBS
STATIC TORQUE IN 100 INCH LBS
UNIVERSAL JOINTS
CURTIS UNIVERSAL JOINT CO INC
SPRINGFIELD MASS U S A
TORSIONAL DEFLECTION IN DEGREES

Torque Curve ½" Curtis Universal Joint

This is only one of many problems solved by Curtis Joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, and over 30 years' experience manufacturing universal joints make them that way.

14 SIZES ALWAYS IN STOCK —
3/8" to 4" O.D. (6" joints on special order)

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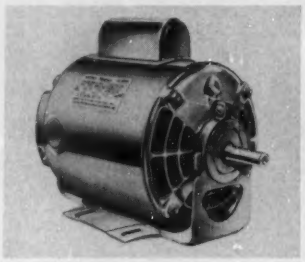
As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 494 on page 19

New Parts

bearing motors at any angle. High-tin babbitt bearings have excellent antiseizure and nonscoring characteristics, high corrosion resistance, and smooth performance with low temperature rise. Mylar paper-



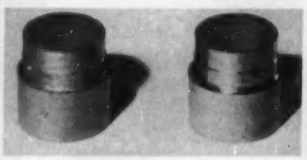
laminated slot insulation assures long life. **Wagner Electric Corp.**, 6400 Plymouth Ave., Saint Louis 14, Mo.

Circle 669 on page 19

Sintered Iron

has free-machining characteristics

Free-machining iron material, Powdiron FM, is pure sintered iron combining excellent machining properties with low cost. Use is for machined bearings and structural parts. Machineability of new material is contrasted here with ordinary sintered iron. Machined



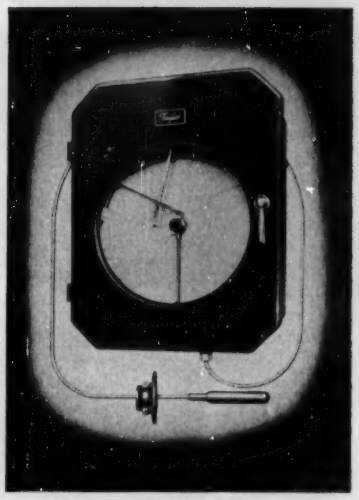
surface of Powdiron FM is comparable to mild steel. **Bound Brook Oil-Less Bearing Co.**, Lincoln Blvd., Bound Brook, N. J.

Circle 670 on page 19

Step Valves

have actuation pressure independent of line pressure

Large, direct air passages give step-valves quick action. With spool-type plunger, effort to actuate valve does not increase with air-line pressure. Valve requires 8¾ lb of force to operate when line pressure is from 30 to 120 psi. Valve bodies are aluminum; plungers are hard-chrome plated steel;



Courtesy Taylor Instrument Companies

LOOK NO FURTHER FOR QUALITY . . .

This Taylor Recording Thermometer, #76JM117, is a one pen mercury actuated recording instrument which includes 5 feet of BISHOP Accuratus* tubing. *(Capillary lengths in excess of 200-feet are not uncommon when the use of Accuratus* tubing is indicated).*

And why BISHOP capillary tubing? Because Taylor uses only the highest *quality* components in its instruments.

The next time you need small diameter stainless steel tubing, look no further for *quality* tubing. BISHOP has it.

Mechanical—Capillary—Hypodermic
Seamless or Welded and Drawn
(.008" to 1" O.D.)

Also, investigate Bishop fabricated parts to save you time and money.

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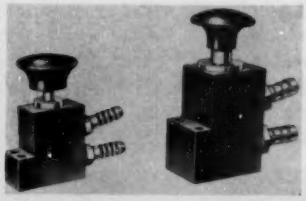
Stainless Steel Products Division
Malvern, Pennsylvania

*Trademark

Circle 495 on page 19



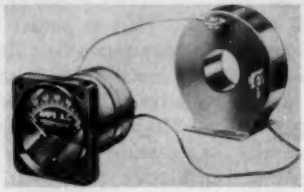
caps, plugs and hose nipples are brass; seals are Hycar. Valves are either spring-return or self-locking type, normally open or closed. **Mead Specialties Co.**, Dept. SV-25, 4114 N. Knox Ave., Chicago 41, Ill.

Circle 671 on page 19

Ammeter

vibration-proof unit has easily read dial

Linear-scale ac ammeter has evenly spaced dial markings which eliminate crowded divisions at end of scale. Deflection of needle is directly proportional to current. Unit is resistant to extreme vibration, shock, moisture, salt spray



and fungus from sea level to 50,000 ft and from −55 to 71 C. Standard model is 200/115 v, 3-phase, 400 cps; special models are available. Ammeter has transformer that converts ac current to 5-ma level. Accuracy is ±2 per cent, power consumption is under 0.05 va at full scale deflection, breakdown potential is 2000 v and overload capacity is 300 per cent. Range is 0 to 115 amp. **Beckman Instruments Inc.**, Beckman/Helipot Corp., Newport Beach, Calif.

Circle 672 on page 19

Thread-Cutting Fastener

cuts threads in die-cast or forged parts

Thread-cutting fastener is designed to hold die-cast or cold-forged name plates, emblems or trim to sheet metal surfaces. Device cuts clean, deep threads on nonthreaded studs. Unit makes a watertight

Best low-cost way to incorporate variable-speed into machine designs

Choose from 8 sizes . . . ¼ to 15 hp . . . 1.75:1 to 4:1 speed ratio. Converts any standard constant-speed motor into variable speed drive.
MAXIMUM TO MINIMUM OUTPUT SPEED POSITIONS

REEVES®

Vari-Speed Motor Pulley

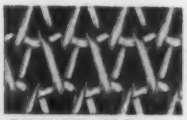
Specify this easy, economical way to efficient and versatile use of the machines you design. REEVES-equipped machines adjust immediately to a variety of production speeds, production processes . . . you substantially reduce design and capacity obsolescence.

Your REEVES representative will be glad to work with you on the application best suited to your design. Offices in principal cities—or write direct for Catalog H28-V545.

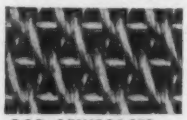
REEVES PULLEY COMPANY
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.
Columbus, Indiana

Circle 496 on page 19

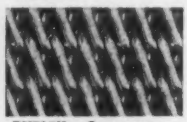
SECTIONAL—Simplest weave, for light loads where low initial cost is desired.



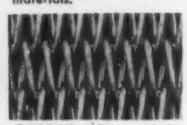
BALANCED—High tensile strength, low ultimate cost belting for operation up to 1300°F. Resists distortion, designed for straight travel.



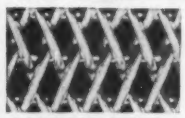
ROD-REINFORCED—Highest tensile strength and low thermal capacity. It is recommended for high temperatures, up to 2100°F. Undergoes minimum elongation and width contraction.



DUPLEX—Compact structure of great density provides high tensile strength. The close mesh provides smooth surface for carrying small parts and plastic materials.



GRATEX—Close spirals retain the advantages of Balanced weave, while adding strength. For cold, medium and some high temperature applications.



DOUBLE BALANCED—A widely used weave combining open mesh of Balanced weave with the strength of Gratex. For cold, medium, some high temperature applications.

MULTI-STRAND

CORDUROY

INTERWOVEN

How to select WOVEN WIRE CONVEYOR BELTS for Continuous Processing

As you know, woven wire conveyor belts are widely used for combining movement with processing in many continuous operations—heat treating metal parts; washing, blanching and freezing food products; annealing and decorating glassware; washing and curing chemicals and plastics.

However, there is no single type of belt construction suitable for all processes. Some require a smooth belt surface, some exceptional strength, others high corrosion resistance. That's why Cambridge has nine basic weaves available. Each is shown here with the important characteristics of the six most frequently used. The last three are special-purpose weaves for installations requiring exceptionally smooth surface and dense mesh for very small parts.

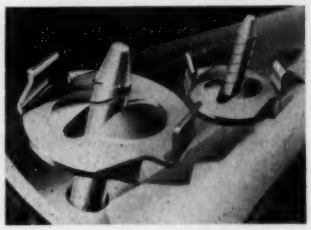
There are several factors that generally influence selection of weave, mesh size and metal or alloy from which the belt will be woven. Among them are: size, weight and shape of product to be handled; temperatures to which belt will be subjected; presence of wet or corrosive conditions. Even after these have been decided, overall belt construction must be designed to meet individual requirements—type of drive, selvage, support and special surface attachments must be selected.

You can see, then, that designing for continuous processing with woven wire conveyor belts is not a simple "nuts and bolts" job. Ramifications build up rapidly to demand the service of a specialist. That's why Cambridge maintains a staff of competent Field Engineers to help you select the Woven Wire Conveyor Belt to make your installation most efficient. You can rely on the experience of these engineers to specify just the right belt for you. In addition, they are thoroughly familiar with basic conveyor design. For the name of your nearest Cambridge Field Engineer, look under "Belting, Mechanical" in your classified telephone book. Or, write direct. Also ask for 130-page Reference Manual of specifications and design information.

THE CAMBRIDGE WIRE CLOTH COMPANY
DEPT. N, CAMBRIDGE 1, MARYLAND

New Parts

seal when used with preassembled plastic sealer. Device is low cost, reusable, self-locking, vibration-proof and, with spring take-up, gives flush mounting on flat or contoured surfaces. Unit is available



to fit ⅛ and 3/16-in. studs. **United-Carr Fastener Corp.**, Carr Fastener Co., Cambridge, Mass.

Circle 673 on page 19

Snap-Acting Thermostat

miniature unit weighs 4 grams

M1 hermetically-sealed, vibration-resistant, snap-acting thermostat has temperature setting range from −65 to 400 F. Unit is preset at factory and is nonadjustable. Ratings are: 7 amp resistive, 30 v ac/dc; 6 amp resistive, 125 v ac; or 3 amp resistive, 250 v ac, depending upon life expectancy. Weight is 4 grams. Insulation resistance is 1250 v ac, 60 cps for 1 min. Unit

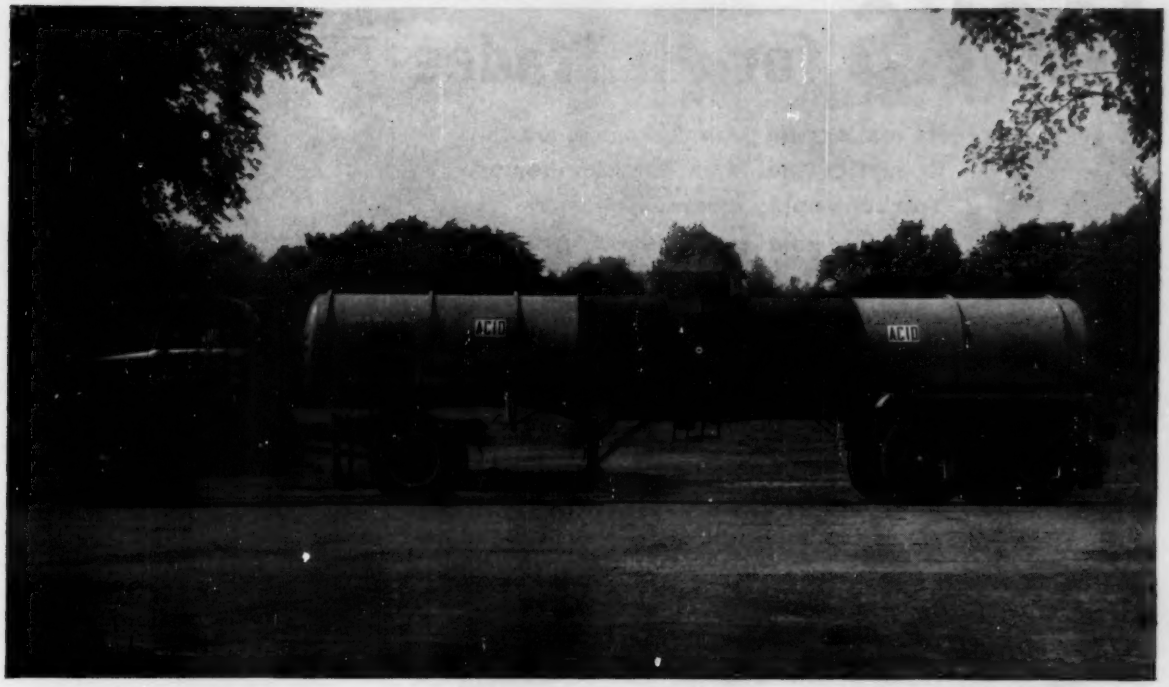
either opens or closes on temperature rise, as desired. Overall height is 0.500-in. **Metals & Controls Corp.**, Spencer Thermostat Div., Attleboro, Mass.

Circle 674 on page 19

Machine Heads

versatile line of standard components

Spindles, slides and feeds for grinding, milling, boring, routing or drilling may be combined to form machine heads for standard or special machine tools. Unit shown has individually-designed base assembled with standard components



Leading tank carrier standardizes on Fuller 8-speed ROADRANGER® Transmissions

Fuller 8-speed, semi-automatic ROADRANGER Transmissions will be *standard* in all new tractors purchased by Leaman Transportation Corporation, Leaman Transportation Company, Inc. and Chemical Tank Lines, Inc. of Downingtown, Pennsylvania.

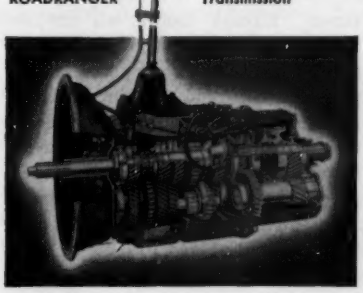
The combination of these three companies comprises one of the largest tank carrier operations in the world. Since 1930 this organization has used hundreds of Fuller Transmissions . . . and recently added 36 new R-46 ROADRANGERS in new White and International Tractors as part of the standardization on this 8-speed model.

Says D. A. (Dave) Ross, Vice President: "We get the best service from the 8-speed ROADRANGERS in our operation. Some have over 150,000 miles on them, and have not been touched. Our maintenance cost is much less . . . in fact, we haven't had any cost to date since we have had *no* trouble.

"50% of all our mileage on the petroleum hauls is with an empty trailer. With the .577 ratio in the rear axle and 10 x 22 tires, we can maintain a good road speed empty in 8th gear . . . at approximately 2000 to 2200 rpm with our gas engines. This results in better fuel mileage and better engine life. And, we are able to maintain a higher rpm at all times under a load. Our drivers now say they wouldn't have any other transmission."

For efficient, dependable operation of your trucks, ask your truck dealer now for full details on the easiest-shifting transmission available for your operation. Specify Fuller ROADRANGER Transmissions for faster trip time, lower fuel consumption, longer engine life, less driver fatigue and greater profits.

Fuller R-46 ROADRANGER Semi-Automatic Transmission



FULLER MANUFACTURING COMPANY
Transmission Division, Kalamazoo, Michigan

Unit Drop Forge Division, Milwaukee 1, Wisconsin • Shuler Axle Company, Louisville, Kentucky (Subsidiary) • Sales & Service, All Products, Western District Branch, Oakland 6, California and Southwest District Office, Tulsa 3, Oklahoma.

Circle 498 on page 19

JACKS for All Trades

100-Ton Hydraulic
Model 100B12

No matter who your customers are . . .
No matter what kinds of jacks they use . . .
You can supply them IF you carry . . .

WESTERN
FORMERLY BUDA **JACKS**

120 Models—9 Types

Ratchet Lowering
Model 2215SB

WESTERN is a *new name* in the jack manufacturing industry, having only recently acquired the jack portion of BUDA Division, Allis-Chalmers Mfg. Co. This old, established, highly-reputable line of 120 models in 9 basic types is wisely and widely diversified and thoroughly complete . . . expertly selected to supply the mass demands of the whole industrial market . . . capacities from 3 to 100 tons . . . closed heights from 6¾″ to 38″. . . lift ranges from 1½″ to 24″. This means every jack is a fast mover because comprehensive user-market analyses pinpoint each as a necessity by many basic industries.

Ball Bearing Journal
Model 2510

But more has been changed than just the name. WESTERN is determined to become the most aggressive jack manufacturer . . . the most attractive to buy from . . . the most profitable to represent. Here's how:

Hydraulic "Two Speed"
Model 25B22

New SERVICE Policy

Authorized Repair Stations strategically located throughout the nation carrying complete stocks of replacement parts. Prompt repair service.

New SALES Policy

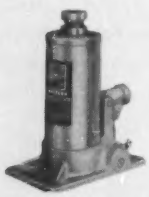
New representatives have been appointed. Territories are set up so representatives can concentrate on proper servicing of selected distributors.

New DELIVERY Policy

WESTERN has built up an inventory of all models, all types. No matter how large an order is placed, deliveries will start immediately.

New DESIGN Policy

WESTERN has announced a 100-ton hydraulic jack—illustrated above. More jacks are on the drawing board . . . others are being redesigned, refined, improved.



Hydraulic "Hi-Speed"
Model 8-9A

New ADVERTISING Policy

Hard-hitting, interest-provoking ads are scheduled in leading industry publications . . . urging users to buy WESTERN Jacks from WESTERN Distributors.

New PROMOTION Policy

Direct mail pieces for distributors to send to their customer lists . . . ample space for imprinting so distributors can tie-in with WESTERN's national advertising.

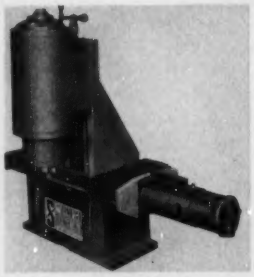
WRITE . . . for Catalog . . . for All Facts

WESTERN RAILROAD SUPPLY COMPANY

Industrial Division—**2400-2434 S. Ashland Ave., Chicago 8, Ill.**

5709

New Parts

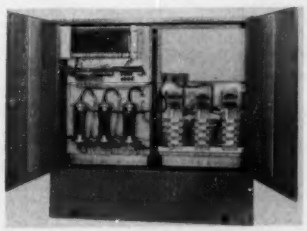


and includes standard feed with hydraulically controlled air cylinder, nonmetallic ways and covers. Head is a standard vertical angle plate with micrometer dial for vertical positioning of two speed 3600/1800 rpm 10/5 hp milling spindle. Spindles are available with all standard tapers. **Standard Electrical Tool Co.**, 2488 River Rd., Cincinnati 4, Ohio.

Circle 675 on page 19

Electronic Speed Control

static unit for motors to 150 hp



Electronic variable-speed control has capacity from 30 to 150 hp. Unit consists of operator's control station, electronic control unit and dc motor. System is ignitron-controlled, 3-phase, full-wave rectifier type with firing circuit, variable field supply, tachometer feedback, and protection and switchgear circuits. Dynamic braking, reversing, forward-reverse-jog operation, acceleration limiting and armature-current limiting are standard features. Except motor, all components are static with no inertial properties to slow response. Unit provides full-field starting, smooth acceleration, and infinitely variable speed over a range of 32:1 with regulation of 1½ percent or closer. **Raytheon Mfg. Co.**, Commercial Equipment Div., 100 River St., Waltham 54, Mass.

Circle 676 on page 19

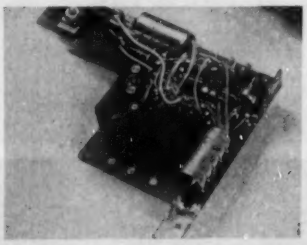
ENGINEERING DEPARTMENT

EQUIPMENT

Timing Generator

has adjustable pulse duration

Timing generator, which can pulse at any rate from 1 to 3000 cps, actuates a neon bulb to establish a time base on film for data-recording camera or similar application. Unit withstands acceleration in ex-



cess of 100 *g* and performs at high vibration levels and high altitudes within temperature range of −65 to 185 F. **Electromation Co.**, 116 S. Hollywood Way, Burbank, Calif.

Circle 677 on page 19

Microfilm System

produces reproductions with better quality than original

New 105-mm microfilm system successfully duplicates engineering drawings as large as 36 x 54 in. sheet size and larger in roll lengths. Second originals are better than true originals, with 75 per cent average improvement (without artwork) for restoration of solid or worn tracings. Negatives do not require corrective opaquing and need no artwork except to delete unwanted features on drawing itself. System yields full-sized second originals on Photact papers, cloth or film of such high quality that original pencil or ink tracing may be destroyed. Negatives are nominally 4 x 6 in., and fit standard 5 x 8 in. filing drawers. System includes screen pro-

(*Continued on Page* 168)

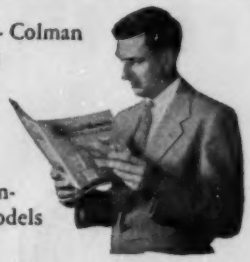
THE MARK OF QUALITY

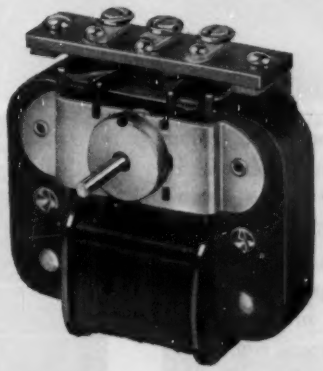
BARBER COLMAN

Small Motors

condensed catalog helps select exact motor needed

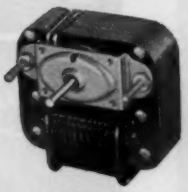
Get this helpful catalog of Barber- Colman a-c shaded pole motors. Designed for applications requiring long life, rugged construction, these quality motors with high starting torque, low-inertia rotors provide quick, positive starting under adverse conditions. Various models of the four types shown below.





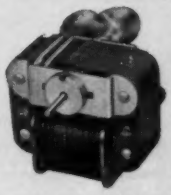
REVERSIBLE MOTORS

Adaptable to a variety of control circuits to meet many different requirements demanding a compact and powerful fast-reversing motor. Widely used for servo-mechanisms, remote switching and positioning devices, voltage regulators, pen drives. Available with gear trains, open or enclosed, in wide range of ratios. Low-inertia rotors permitting rapid reversing and follow-up make these motors ideal for many electronic control circuits.



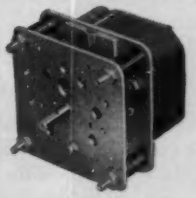
UNIDIRECTIONAL

For driving pumps, projectors, blowers and fans for refrigerators, gear trains for vending and office machines, etc.



SYNCHRONOUS

For chart drives, timers, microfilm cameras, oscillographs, and similar applications.



GEARED

For vending and office machines, rotisseries, TV tuners, program switches, etc. Model shown for overhanging loads.

the complete line of Barber-Colman motors includes unidirectional, synchronous, and reversible motors — up to 1/20 hp. With and without reduction gearing — open or enclosed types. Expert engineering service available to help you get the exact motor for your application. Write today for your free copy of Catalog F-4271-6.

BARBER-COLMAN COMPANY

Dept. M, 1273 Rock Street, Rockford, Illinois.

Small Motors • Automatic Controls • Industrial Instruments • Aircraft Controls • Air Distribution Products
Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Hyatt's Simplified Fitting Practice for Bearing Races

HYATT pioneered the use of carburizing type alloys in order to obtain the advantages of heavier race fits

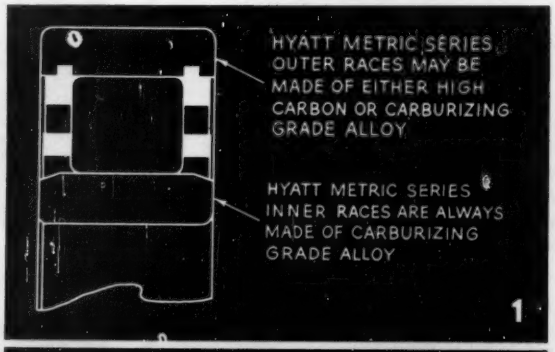
To obtain the best possible performance, roller bearing races must be assembled on shafts and in housings with certain fits developed by design and experience. The most frequent condition to be met is a rotating shaft where specific load and speed conditions must be satisfied with appropriate race fits. These vary according to the manufacturer, and in the case of some manufacturers, according to the application. Naturally, the fits will also vary according to bearing type and size.

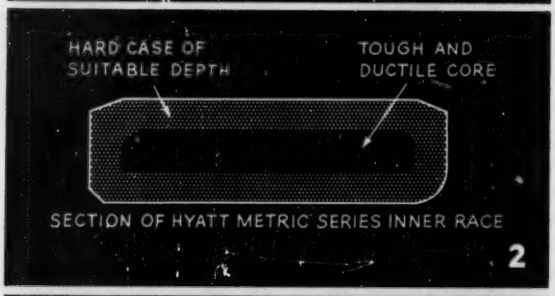
1. CARBURIZING PERMITS HEAVIER INTERFERENCE FITS

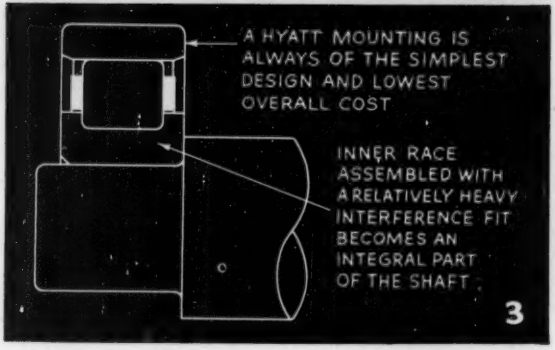
Taking the standard metric series of cylindrical roller bearings for an example, the bearing user has the choice of two fitting practices. One involves the use of inner races made of through-hardening steel, which dictates fairly light interference fits to avoid splitting. The other utilizes races made of low carbon steel *carburized* and hardened to develop a suitable surface hardness and a tough ductile core. The latter permits much heavier interference fits and has the additional advantage of eliminating all auxiliary holding devices, because the race becomes practically an integral part of the shaft. (Figs. 1, 2.)

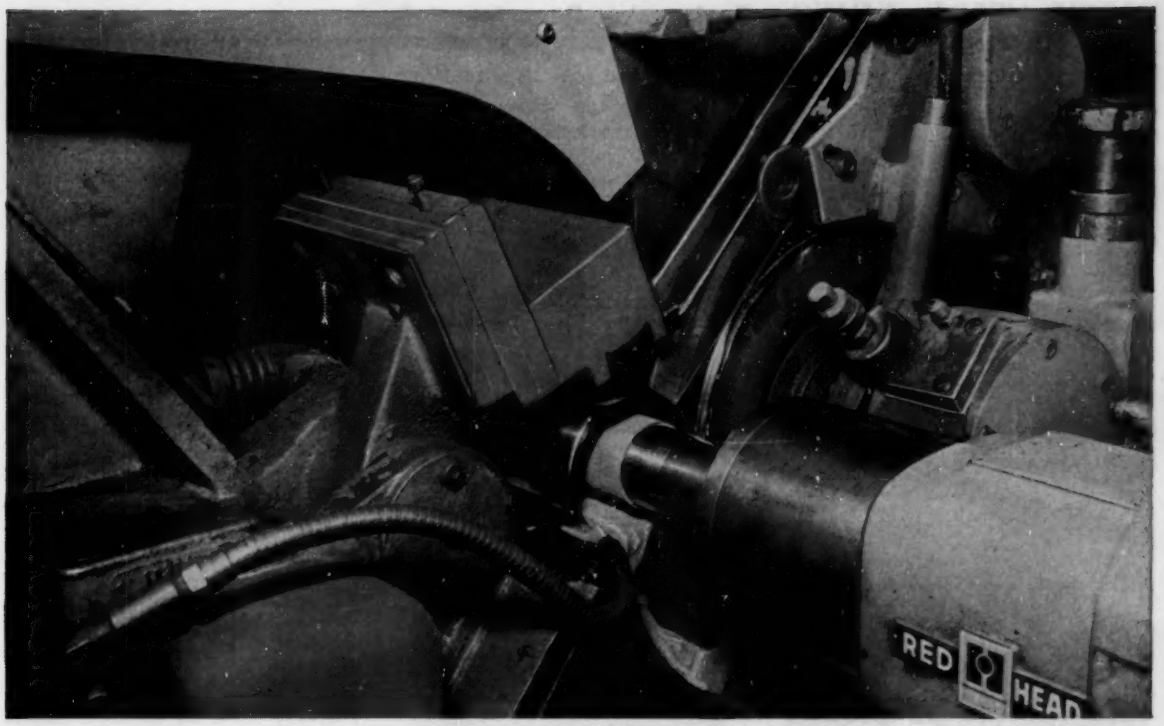
2. HEAVIER FITS SIMPLIFY MOUNTING, REDUCE COSTS

Hyatt originated the carburized race and the system of relatively heavy inner race fits to simplify bearing mounting and eliminate the need for retaining devices. Practically all HYATT inner races are made from nickel alloys of the carburizing type. They permit mountings of the simplest type and lowest over-all cost. Furthermore, the shoulders of HYATT carburized races will withstand considerably greater impact loads than will ordinary races. (Figures 3 and 4.)


HYATT METRIC SERIES OUTER RACES MAY BE MADE OF EITHER HIGH CARBON OR CARBURIZING GRADE ALLOY
HYATT METRIC SERIES INNER RACES ARE ALWAYS MADE OF CARBURIZING GRADE ALLOY
1




A HYATT MOUNTING IS ALWAYS OF THE SIMPLEST DESIGN AND LOWEST OVERALL COST
INNER RACE ASSEMBLED WITH A RELATIVELY HEAVY INTERFERENCE FIT BECOMES AN INTEGRAL PART OF THE SHAFT
3

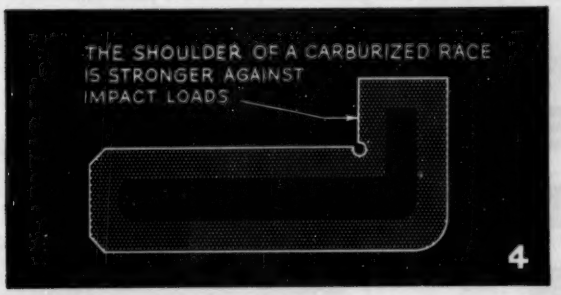


Hyatt inner race being centerless I. D. (inside diameter) ground to close tolerances.

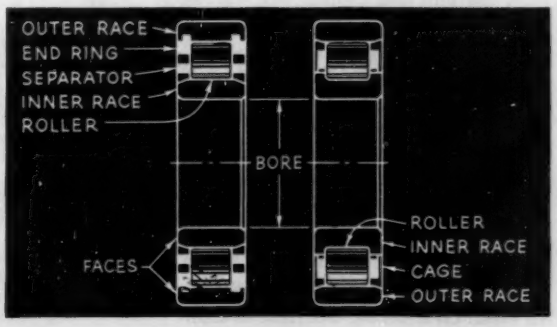
There are two fitting specifications which apply to HYATT inner races, depending on whether the inner race rotates or is stationary in operation. Remember, with both inner and outer race, the rotating member is assembled with heavier fit.

3. HYATT INNER RACES CAN BE EASILY SHRUNK ON SHAFTS

HYATT inner races may be mounted on shafts by pressing or shrinking. Where shrinking practice is employed, first heat the race in oil held at a temperature not over 300°F, or in an electric oven under a similarly controlled temperature, until it expands sufficiently to be slipped into position. The required interference fit will develop as the race cools in place. For special conditions of fit involving hollow shafts of varying sections or multiple housings of dissimilar metals, consult your HYATT Sales Engineer from our nearest sales office.



COMPONENT PARTS OF A HYATT ROLLER BEARING

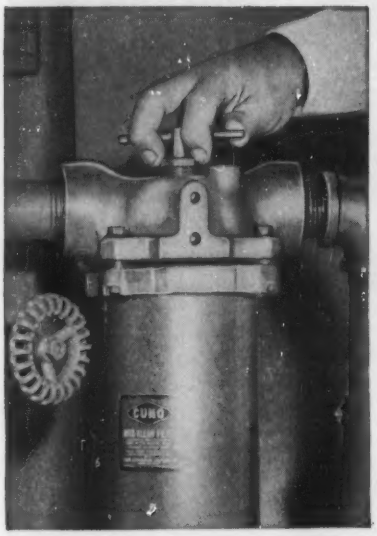


YOU WILL FIND MORE DETAILS in HYATT Catalog No. 150. If you do not have a copy, write Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey. Sales offices at Harrison, Pittsburgh, Chicago, Detroit and Oakland, California.

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

FILTRATION NEWS



Filter to 40 microns, turn handle to clean!

You can clean this 40-micron filter simply by turning the handle at intervals—or turn shaft continuously with motor drive.

It's Cuno's SUPER Auto-Klean—using a completely new principle in metal edge-type filtration.

For compact, economical engine fuel and lube, machine-tool coolant and cutting oils, and a wide variety of process fluids, SUPER Auto-Klean offers:

Complete protection against solid particles larger than 40 microns—actually 0.0015". Can't rupture or channel.

No cartridge changes—just turn handle frequently to clean and, at intervals, remove plug and drain sump.

Low pressure drop—3 psi drop with flow rate to 45 gpm for 8" long by 2¼" diameter cartridge and fluid of 200 SSU viscosity.

All metal construction—available in stainless steel for corrosion-resistance.

Standard housings—available with Cuno's standard AUTO-KLEAN housing; available also for integral sump mounting.

Write today for complete data on this outstanding Cuno filter development. Ask for Catalog SAK-057. The Cuno Engineering Corporation, 14-1 South Vine Street. Meriden, Conn.

63

CUNO ENGINEERED FILTRATION

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge)
FLO-KLEAN (wire-wound) • PURE-KLEAN (porous stainless steel)

Circle 502 on page 19

Engineering Department Equipment

(Continued from Page 165)

jectors, table-top viewers with 8 x 12 in. surface and large-sized viewing tables for drafting room use. **Micro-Master Inc.,** Kansas City, Mo.

Circle 678 on page 19

Accelerometer

measures accelerations in two planes

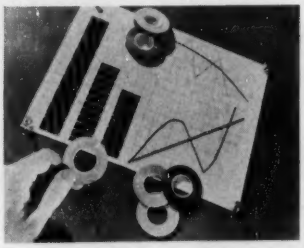
Small, lightweight potentiometer-type accelerometer measures lateral accelerations in two mutually perpendicular planes. Instrument will operate at temperatures from −10 to 1800 F. Unit is available in ranges from ±2 *g* and ±30 *g*. **Genisco Inc.,** 2233 Federal Ave., Los Angeles 64, Calif.

Circle 679 on page 19

Graph-Making Tapes

speed graph and chart-making

Graph and chart-making is speeded with self-adhesive acetate-fiber tapes in various widths, colors and designs which are readily applied to any surface.



Narrower widths can be curved easily. Tapes come in 15 colors, 6 widths from 1/32 to 1 in., and 9 striped designs. **American Chart Service Inc.,** 101 Dover St., Somerville 44, Mass.

Circle 680 on page 19

Voltage Generator

for low frequency analysis purposes

Random voltage generator produces low frequency noise with controlled power frequency spectra and predetermined amplitude prob-

ADVISORY LEVEL POSITION FOR MECHANICAL STANDARDS ENGINEER

The Missile and Ordnance Systems Department of General Electric, prime contractor for the ICBM and IRBM nose cones, now has an excellent position available on its staff for a Mechanical Standards Engineer with proven analytical ability capable of working effectively with different individuals and groups.

Position Responsibilities: Develop departmental mechanical components standards; participate in company, industry, professional society, and government standards work. Advise all elements of the department regarding mechanical engineering standards.

Position Requirements: At least five years' experience in mechanical engineering standards at professional level, or at least eight years' mechanical engineering design and manufacturing engineering experience, at least two years of which were concerned with machine parts and components rather than with systems and products.

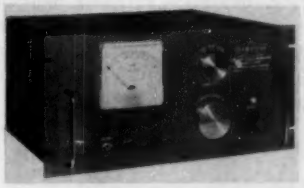
Salary and benefits are liberal, and the facilities and equipment are excellent. We hold prime contracts of a long-term nature with all of the armed services. Our Manager of Engineering Administration will review your resume and, if your qualifications are appropriate, invite you to visit our Philadelphia location at our expense for a personal interview. If you prefer, you need not reveal your present employer.

Please send resume in confidence to:
Mr. John Watt, Technical Recruiting, Room 570-1

MISSILE & ORDNANCE SYSTEMS DEPARTMENT
GENERAL ELECTRIC
3198 CHESTNUT STREET, PHILADELPHIA 4, PA.

Circle 503 on page 19

ability characteristics. Unit is available in six models covering frequency range from 0.01 to 5000



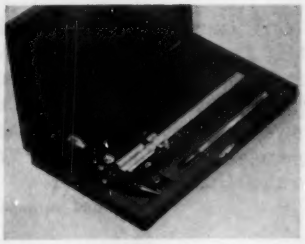
cycles and to 1 and 5 megacycles. White noise produced has power frequency spectra flat within 1 db at all frequency ranges. **Intercontinental Dynamics Corp.**, 170 Cooledge Ave., Englewood, N. J.

Circle 681 on page 19

Vernier Compass

gives 24 in. diam circle with 0.001-in. accuracy

Precision layout beam-compass and scriber with 12 in. scale provides 24-in. diam circle. Vernier gives



accuracy to 1/128-in. or 0.001-in. Both legs of compass are fitted with removable phonograph-needle points to produce extremely fine lines. Unit comes with hardwood case and extra needles. **Titan Tool & Supply Co. Inc.**, Dept Q, 1419 Hertel Ave., Buffalo.

Circle 682 on page 19

Sonic Gas Analyzer

is ultrasensitive unit with wide range

Differences in the velocity of sound in various gases are measured by frequency shift in a sonic gas analyzer. Featuring exceptional range and rapidity of analysis,

- **Easy to install...simple to service!**
- **No troublesome protective relays!**
- **No flashing contactors!**
- **No complicated electronic adjustments!**

Specially designed for machines where friction or torque is constant from high to low speed. Motor-generator set, controller and drive motor can be mounted independently, in any position.

- *One* control for all adjustments. 0 to 2400 RPM in 30 steps of 80 RPM, forward or reverse.
- Totally enclosed Streamcooled construction . . . vernier rheostat for infinite speed control between steps . . . jog switch for machine adjustments . . . reversing switch changes rotation . . . many other features.
- Ideal for use on conveyors, pumps, mixers, shaker screens, packaging machines, fans and blowers, farm machinery, governor controls, similar machines.

For complete engineering data write for Bulletin SP-600

BALDOR ELECTRIC COMPANY
4353 DUNCAN AVE. ST. LOUIS 10, MISSOURI

Circle 504 on page 19

On which of these can you use help?	OK here	Can use help
PRODUCT DESIGN & DEVELOPMENT		
MANUFACTURING COST ANALYSIS		
PRODUCTION PROCESSING		
TOOL & DIE DESIGN		
MACHINE DESIGN		
TIME STUDIES AND ANALYSIS		
AUTOMATION DEVELOPMENT		
PLANT LAYOUT & SPECIFICATIONS		
PRODUCTION & QUALITY CONTROL		

Handy Check List for Executives and Chief Engineers

If you have a single check in the "can use help" column, you need the services of Pioneer Engineering & Mfg. Co. Our complete, contract engineering services are available when and where you need them. For more information, contact our chief engineer. He'll see that you get it immediately.

SINCE 1931 **Pioneer ENGINEERING & MANUFACTURING CO., INC.**
Telephone - TWinbrook 3-4500
19669 John R Street, Detroit 3, Michigan

INDUSTRIAL ENGINEERS, CONSULTANTS & DESIGNERS
BRANCH OFFICES IN DAYTON, OHIO, WASHINGTON, D. C. and TORONTO, ONT., CAN.

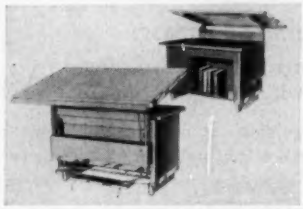
the unit has sensitivities as high as 0.005 per cent of oxygen and 0.00061 per cent of hydrogen in air. Sensitivity remains constant over complete range of instrument. **National Instrument Laboratories Inc.**, 6108 Rhode Island Ave., Riverdale, Md.

Circle 683 on page 19

Drafting Table-Desk

provides efficient use of floor space

Drafting-reference unit allows flexible, productive use of floor space. Stacor-Matic table serves man in front as reference facili-



ty and man behind as drawing table. Drawing table has wide-range height and slope adjustments. Reference section has drawer and file space. **Stacor Equipment Co.**, 768 E. New York Avenue, Brooklyn 3, N. Y.

Circle 684 on page 19

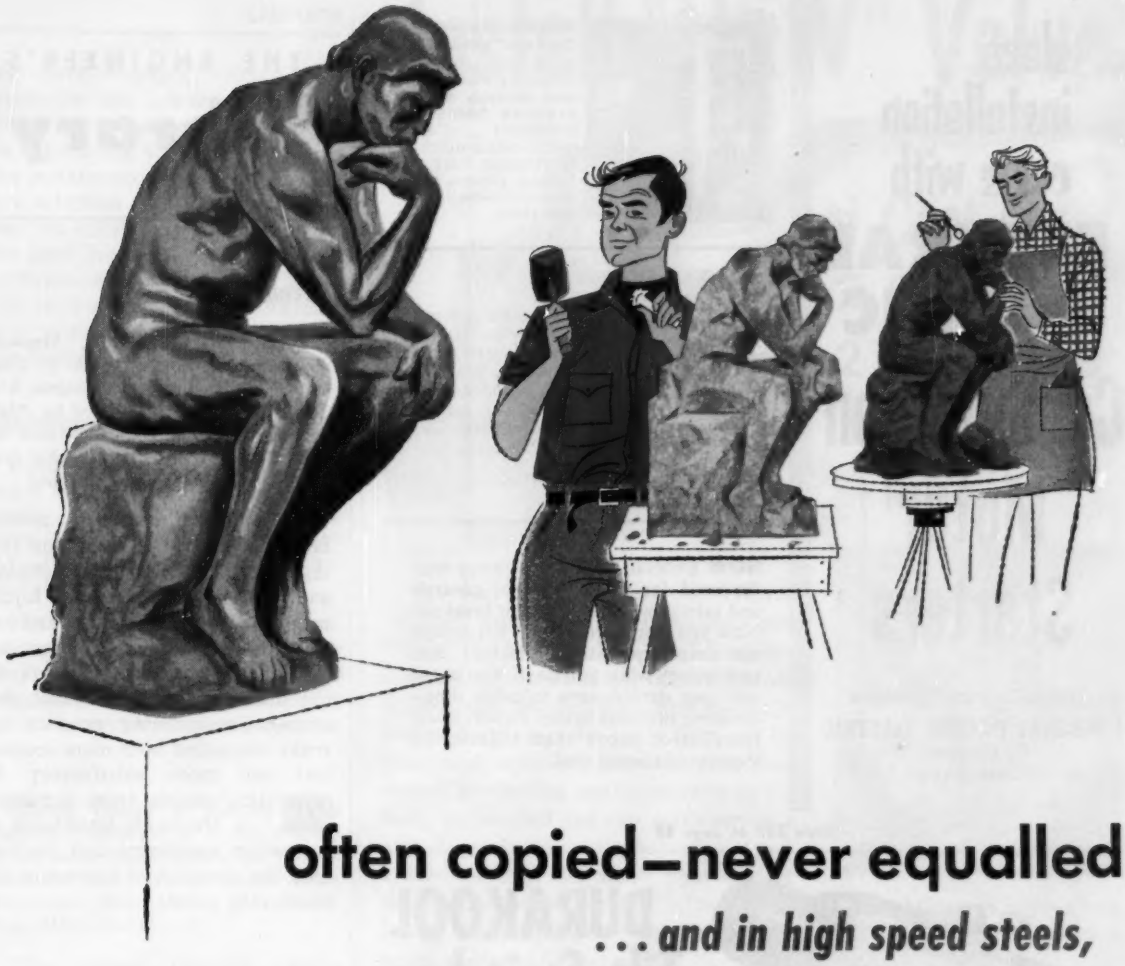
Temperature Control

is ultrasensitive unit with ± 0.5 per cent accuracy

Sensitivity of thermistor bridge circuit is combined with the dual indicating and controlling functions of a contact meter-relay in

a temperature control package. Unit acts upon temperature change of only 0.075 F. Range is −103 to 572 F. Indicating accuracy is ± 0.5 per cent of full scale. **Assembly Products Inc.**, Wilson Mills Rd., Chesterland, Ohio.

Circle 685 on page 19



often copied—never equalled

. . . and in high speed steels, nothing has ever equalled REX

Crucible's REX® high speed steel is in a class by itself—has been for more than half a century. And it gets better every year. New improvements in manufacturing techniques have brought even greater uniformity and quality to its well-known properties.

But prove this for yourself—shop-test the new REX in your own plant. Check its structure, uniformity, response to heat-treatment—all-around tool performance. Try REX any way you like—you'll see for yourself why the new REX is still the *standard for comparison* in every high speed steel application.

You can get REX from stock from your nearby Crucible warehouse—or promptly by direct mill delivery. For further information on REX and the many other Crucible special purpose steels, send for the *Crucible Publication Catalog*—it's yours for the asking. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

slash installation costs with

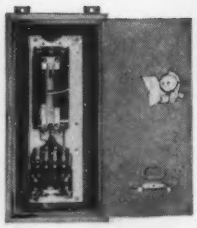
FEDERAL PACIFIC

Combination Motor Starters

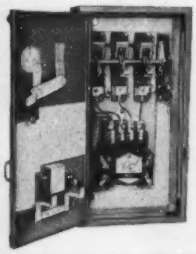
Finest Products Engineered

FEDERAL PACIFIC ELECTRIC COMPANY

50 Paris Street, Newark 1, N. J.



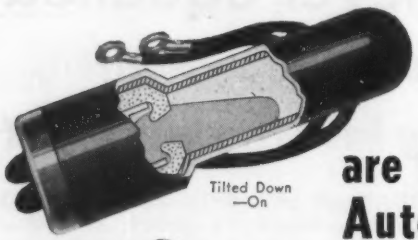
THERMAL MAGNETIC CIRCUIT BREAKER permits harmless temporary overloads; trips instantly when overload becomes dangerous... offers quick-make, quick-break action, thermal tripping element and deionization arc quenchers.

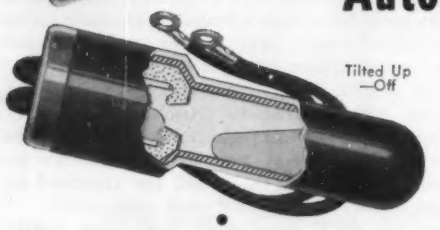


DISCONNECT SWITCH designed for cool operation, safety and long life. Features clear visibility, positive circuit opening and silver plated current carrying parts.

NOW Federal Pacific does away with the need for separate motor controls and safety switches or circuit breakers! Now you can meet all your needs with one simple space-saving device... and save money while you do it! You install only one device—save valuable time—conserve precious space! Faster, easier installation more than offsets the slightly additional cost.

Circle 507 on page 19





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Durakool ALL-STEEL MERCURY Switches

Circle 508 on page 19

THE ENGINEER'S Library

Recent Books

Engineering Inspection, Measurement and Testing. *By H. C. Town and R. Colebourne;* 192 *pages,* 6 *by* 9 *in., clothbound; published by Philosophical Library Inc.,* 15 *E.* 40*th St., New York* 16, *N. Y.; available from* MACHINE DESIGN, $8.75 *postpaid.*

This book describes modern methods of measurement and testing and is intended for student and practicing engineers. Equipment used for dimensional and surface finish inspection are described. The chief value of this book for the designer lies in the fact that proper dimensioning practice can make inspection both more economical and more satisfactory for separating usable from nonusable parts. A thorough knowledge of inspection equipment and methods aids the selection of tolerances and measuring points.

Cobalt File. 108 *pages,* 8½ *by* 11 *in., paper covers,* 3*-hole punched loose leaf; published by and available on letterhead request from Cobalt Information Center, Battelle Memorial Institute,* 505 *King Ave., Columbus* 1, *O.*

The purpose of this compilation is to present in one place the phase diagrams and references for all cobalt systems. Included are reports of considerable research on allotropy of cobalt and on binary and more complex systems with cobalt.

Applied Metallurgy for Engineers. *By Malcolm S. Burton, School of Chemical and Metallurgical Engineering, Cornell University;* 407 *pages,* 6 *by* 9 *in., clothbound; published by McGraw-Hill Book Co. Inc.,* 330 *W.* 42*nd St., New York* 36, *N. Y.; available from* MACHINE DESIGN, $7.50 *postpaid.*

This text describes the metallurgical principles involved in cast-

ing, metal working, welding, heat treatment and powder metallurgy. These processes are discussed from an engineering viewpoint, including the metallurgical factors that control selection of suitable processes and the influence of the process on the final product. Recently developed processes such as shell molding, inert-gas shielded-arc welding and vibrationless midair forging are included.

Manufacturers' Publications

Westinghouse Ready Guide. *44 pages, 8½ by 11 in., paperbound, sidestapled; published by and available from Westinghouse Electronic Tube Div., Dept. T-286, Route 17, Elmira, N. Y.; 35c per copy.*

Booklet presents over 450 receiving tubes representing 95 per cent of tubes used in radio and television circuitry. Tube-socket diagrams appear on same page with data.

Casting Design as Influenced by Foundry Practice. *64 pages, 8½ by 11 in., paperbound; published by and available on letterhead request from Meehanite Metal Corp., 714 North Ave., New Rochelle, N. Y.*

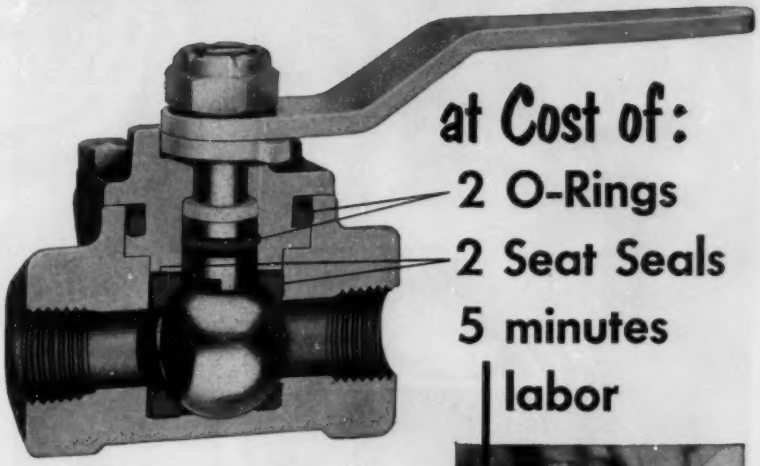
This manual provides usable working data on casting design. It treats the form of design, the method of making patterns, molding procedure, characteristics and behavior of metal in the mold, and other elements involved in design and production of sound castings.

Government Publications

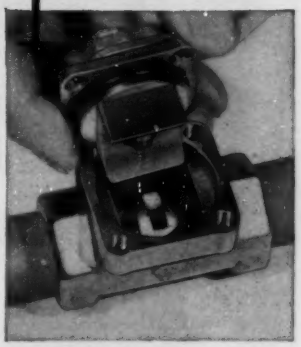
Technical Problems Affecting National Defense. *28 pages, 8 by 10½ in., paperbound, sidestapled; available from National Inventors Council, U. S. Department of Commerce, Washington 25, D. C.*

This report is a cumulative reprint, with current corrections and additions, of earlier lists of fields in which inventions or research is desired. Problems are furnished to the Council by branches of the armed services. The Council assumes responsibility for correspondence, interviews, and related work with inventors until a specific proposal is achieved. The Council

Install "NEW" Valve



at Cost of:
2 O-Rings
2 Seat Seals
5 minutes labor



That's all it takes for easy TOP ENTRY "in-line" maintenance of Worcester's new TWIN SEAL BALL VALVE. To replace sealing components, simply remove the four bonnet bolts, and then the bonnet assembly. Ball and seat rings are easily lifted out by using hook in the hole provided in the stem slot. After cleaning seating surfaces in the body, replace ball and new seat rings as a unit. A new O-ring at the bonnet joint and around the stem will assure tight seals at these critical points. Result? . . . "factory tight" sealing tolerances in your long lasting Worcester TWIN SEAL Ball Valve . . . plus flexibility of seat selection to suit a great variety of media.

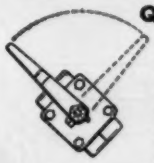
OTHER OUTSTANDING FEATURES

TWO-WAY FLOW

Two-way Flow . . . with positive shut-off . . . will hold nearly perfect vacuum. There is no danger of "wrong way" installation.

With opening in ball and seat rings maintaining same smooth shape as inside of pipe, resistance to flow is well below that of other valves and friction loss is reduced to a minimum.

QUICK OPERATION



The TWIN SEAL Valve goes from fully opened to fully closed position with only a quarter turn of handle and operator knows instantly position of ball and degree of closure. Valve adapts itself readily to remote control and mechanical operation.

FORGED CONSTRUCTION

Lack of porosity, closely held tolerances, absence of stress concentrations and the best possible material flow are some of the advantages of forged construction offered in Worcester's Twin Seal Ball Valve.

This valve is available in naval bronze and aluminum bronze. Seat material may be selected from Buna N, Neoprene, Natural Rubber, Teflon and Kel F allowing this valve to handle Water, Air, Propane, Oxygen, Chemicals and a great variety of other media.

Ball
Gate
Needle
Valves

WORCESTER

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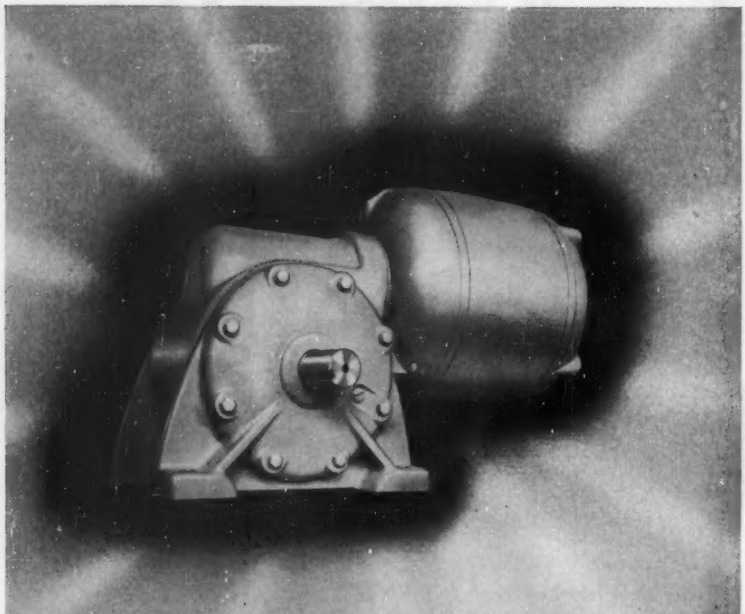
Circle 509 on page 19



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Shaft Mounted
¼ to 5 hp

Library

then arranges direct contact with the proper service for investigation and appraisal.

Evaluation of High Strength Weldable Titanium-Base Alloys, PB 121069. *By C. Robert Little, Armour Research Foundation of Illinois Institute of Technology; 54 pages, 8 by 10½ in., paperbound; prepared by Wright Air Development Center, available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; $1.25 per copy.*

This report describes investigations of six titanium-alloy compositions to determine their suitability as high-strength weldable sheet for use at elevated temperatures. The tests included tensile strength after heat treatment, both at room temperature and at 700 and 900 F, in welded and unwelded conditions. Bend tests were made at room temperature to determine formability of the welded and unwelded material.

Development of Heat Resistant Alloys by Powder Metallurgy Techniques, PB 121356. *By G. Zuromsky, L. Sama, H. Kalish, and L. Seigle, Sylvania Electric Products Inc., 66 pages, 8 by 10½ in., paperbound; prepared by Wright Air Development Center; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; $2.00 per copy.*

This report describes the investigation of the possibility of powder metallurgical techniques to produce cobalt-chromium-tungsten alloys which could meet a minimum 100-hour rupture life at 870 C of 25,000 psi and at 925 C of 20,000 psi.

U. S. Naval Ordnance Laboratory Reports. *8 by 10½ in., paperbound, sidestapled; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.*

Magnetic Properties of Low Permeability Alloys. PB 121169, 11 *pages,* 50c *per copy.*

Transition from Development to Production. PB 121170, 6 *pages,* 50c *per copy.*

Experimental Production of Thin Ferrite Films and A Survey of the Magnetic Properties of Thin Films. PB 121177, 41 *pages,* $1.25 *per copy.*

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- Belt's rated horsepower is all *working* horsepower;
- Bearing loads are minimized, and wear reduced;
- Take-up adjustments are eliminated.

Less belt-pulley contact area is needed, therefore:
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Circle 512 on page 19

New Machines

Metalworking

Tube Bending Machine: High-speed automatic machine bends up to 2-in. diam steel tubing to adjustable bend angles up to 180 deg. Tubing is bent automatically in a vertical plane. The machine utilizes a single-rotation, hydraulic rotary actuator to provide smooth, continuous power throughout the bending operation. Two-pump hydraulic system controls a 2000-psi clamping system and a 1000-psi bending system. All electrical and hydraulic power units and controls are JIC-mounted in the base of the machine. Both manual and automatic cycle controls are included in the pushbutton control panel. *Walter P. Hill Inc., Detroit.*

Grinding Machine: Type LCTU 30-in. semiautomatic cylindrical grinder for grinding large, lightweight workpieces is available in work lengths of 48, 72 and 96 in., and will handle work up to 30 in. in diameter. Wide tables and ways provide rugged support to the work. Wheel spindles run in pressure-lubricated bearings. Automatic or manual wheel feed settings are speeded with a wheel feed index. Feed increments to 0.0001-in. in work diameter reduction are set without visual attention. Wheel feed is accomplished by a rotating screw-type automatic wheel feed mechanism. Automatic cycle is actuated with a single lever, and terminates either manually or by an electrically timed control. Jogging lever permits fractional rotation of the work to the most convenient position. Separate table speeds can be maintained for truing and grinding as set from the first workpiece. *Norton Co., Worcester, Mass.*

Drilling Machine: Deep hole machine drills to a depth of 24 in. with maximum drift of 0.001 to 0.0015-in. per foot of depth, depending on the quality of the workpiece. Drill spindle operates over a 36-sq ft area without resetting

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material. Rapid indexing controls eliminate layout and drill jigs. Use of a single flute gun drill, with provisions for a coolant-wash combination, permits continuous penetration without retraction for clearing chips. Drill spindle, with integral dc motor, is activated hydraulically and is infinitely adjustable within a range of 300 to 5000 rpm. Drill bushing adjusts from zero to 12 in. longitudinally. *Lahr Machine & Tool Corp., Toledo, O.*

Notcher and Punch: Air-powered notching and punching machine has a 6½-ton capacity and 4¾-in. throat. It can be equipped with a variety of punches and dies for simple or intricate holes, corner trimming or combination trimming and cutoff. Foot valve frees both hands for locating and feeding material. Ram can be lowered gradually to locate work at prick-punched points and to facilitate die changing. Throat permits notching and punching well inside the edge of the sheet. Optional equipment includes floor stand, feed table with adjustable squaring edge, and a variety of notching and punching attachments. The machine operates on a pressure of 80 psi. *Niagara Machine & Tool Works, Buffalo.*

Boring Machine: Supermill 3-in. horizontal boring machine permits machining of almost any material with high-speed steel, carbide and ceramic tools. Jib crane-mounted facing head swings away to the rear of the machine when not in use. It has 11 power feeds in either direction from 0.001 to 0.165-in. per revolution, and can be attached to the headstock by swinging it around. Headstock spindle is free to pass through the facing head so that the unit can be used for facing and boring simultaneously. All controls are centrally located on the front of the headstock. Standard machine has 18 feeds and 16 speeds, with all necessary change gearing enclosed in the headstock. It has a built-in rotating table that enables clamping of the work at any desired angle. Standard spindle-to-table height is 31 in. and table has a cross travel of 40 in. Drive unit

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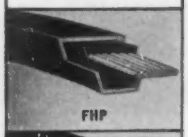
DARCOVA — THE ORIGINAL COMPOSITION CUP

TRADE MARK PUMCUPS

Circle 513 on page 19

Mor-Crip v-belts



Maurey *engineers* v-drives for every situation; the "stop and go" spurts of refrigeration drives; the pulsating, high torque loads of rock crushing; the smooth, steady-pull of textile drives... for short centers, and wide range of speed ratios. Maurey V-drive equipment has proved its value since 1917, improving the performance, and increasing the sales of thousands of products. Maurey delivers pulleys, belts and accessories *quickly* from complete stocks. Whether you are designing a new v-drive or improving an old one, contact Maurey. Call your local Maurey Distributor, or write direct.

Request These Catalogs

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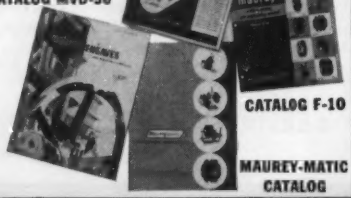
CATALOG MVD-56



CATALOG F-10

MAUREY-MATIC CATALOG

Pulleys, Sheaves V-Drive Accessories

maurey manufacturing corp.

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New Machines

for the automatic feed of the table is built into the base. The machine is also available with capacities of 2, 3½ and 4 in. *S & S Machinery Co., Brooklyn, N. Y.*

Strip Mill: Model TAL-625 four-high reversing cold strip mill produces thin-gage strip up to 8 in. wide from ferrous and nonferrous materials such as carbon and stainless steels, beryllium copper, titanium, and aluminum alloys. Mill operates at speeds up to 500 fpm and holds thickness tolerances to ±0.0001-in. consistently. Rapid roll changing is facilitated by a backup drive which also makes possible change in work roll diameter without affecting linear rolling speed of the mill. Backup rolls are 8 in. in diameter, work rolls are 2½ in. maximum diameter, and both are available in 8 or 10-in. face widths. Rolls are driven through torque arms from a totally enclosed pinion stand. The mill is powered by an adjustable speed drive, comprising one 20-hp mill motor and two 20-hp coiler motors. Electrical equipment also includes control panel, power unit, and electronic tension controls. *Stanat Mfg. Co., Long Island City, N. Y.*

Plant Equipment

Air Compressor: Model 104 is a 2½ x 2 duplex cylinder compressor operating on ¾, 1 or 1½ hp. It provides pressure up to 150 lb and 10.4 cfm. The unit is suitable for small-capacity use by industry, farms and service stations for continuous or intermittent pressure. *E. L. Smith & Sons, Quincy Ill.*

Motor - Generator Set: Fifty-kilowatt, 400-cycle motor-generator set meets Air Force specifications as MD-4 precision power unit. A two-bearing unit housed in a single frame, it consists of a 1200-rpm synchronous drive motor and generator. Motor and generator are rectifier excited. Close voltage regulation is accomplished with a magnetic amplifier regulator. All components of the static rectifier, voltage - regulator system are mounted within one end cover and cooled by incoming air stream. Control panel mounted on the motor - generator base houses meters, field application devices

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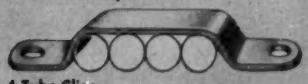
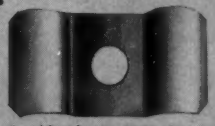
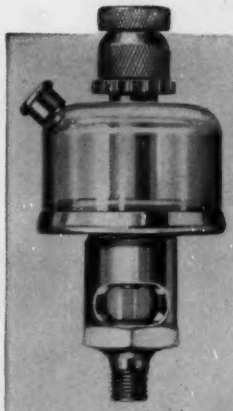
3-Tube Clips



4-Tube Clips



Double Clips — Wing Type

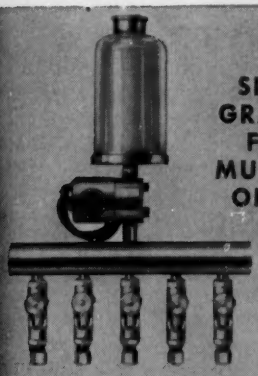


SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

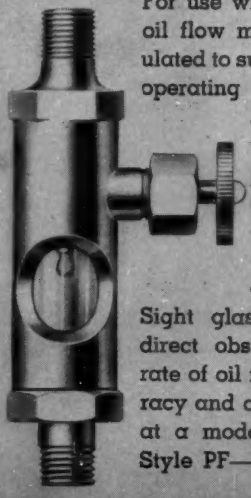
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.



SIGHT GRAVITY FEED MULTIPLE OILERS

This one unit replaces 3 to 8 individual oilers. Maximum practicality in a small central lubrication system. Positive cut-off during idle periods. Individual vibration-proof needle valve adjustments. With solenoid control (Illustrated): Style MDS—No. 4685-A. Without solenoid: Style MD.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

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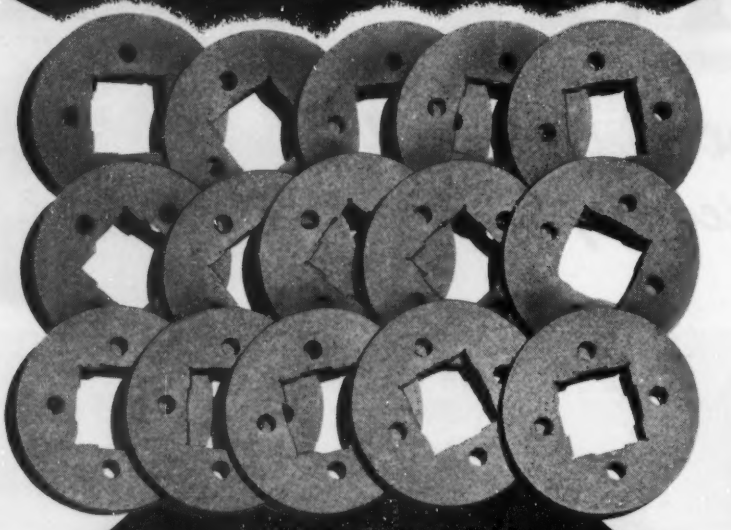
Clip this page for handy "rough reference".

Circle 515 on page 19

What are these—

and what do they mean to you?



(HINT: *They're not Chinese coins or old street car tokens*)

★ Clue No. 1	★ Clue No. 2	★ Clue No. 3
They remain flat, retain their characteristics of long wear — remain tough under stress of pressure or heat.	Designed as the only wearing, moving part of a piece of equipment used for connecting and controlling machinery and its source of power.	They are one of only three prime parts of that piece of equipment.

If your answer is friction linings from Stearns electro-magnetic clutches — you're right!

As the clues tell, the friction lining is the *only* wearing part of a Stearns clutch — and it seldom, if ever, needs adjustment or replacement. This is one of the big reasons that Stearns magnetic clutches have earned the reputation among users of being trouble-free.

On Stearns magnetic clutches, wear *increases* rather than decreases torque. Fast, smooth engagement and even pressures over a large area eliminate distortion and permit long, hard starts without overheating. If required, adjustments for wear are made easily, in minutes.

There are over 100 standard Stearns magnetic clutches and clutch-brake combinations for matched-to-the-machine performance. For special applications, Stearns also designs custom-built units. 17

For complete data on trouble-free Stearns electro-magnetic clutches, call your local Stearns sales representative — or write for bulletin No. 226-EF.

BRAKES MILWAUKEE Stearns WISCONSIN CLUTCHES

ELECTRIC CORPORATION

120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN

New Machines

and other components. Input to the motor is 220/440 v, 3 phase, 60 cycle. Output from the generator is 120 v single phase, or 120/208 v, 3 phase, 0.8 power factor, and 400 cps. Voltage regulation provides sensitivity of ±2 v (120-v base), 1 per cent modulation, transient limits of ±35 per cent and recovery in 0.2 seconds or less. Maximum harmonic content is 2 per cent rms under any load within the rating of the generator. *Electric Machinery Mfg. Co., Minneapolis.*

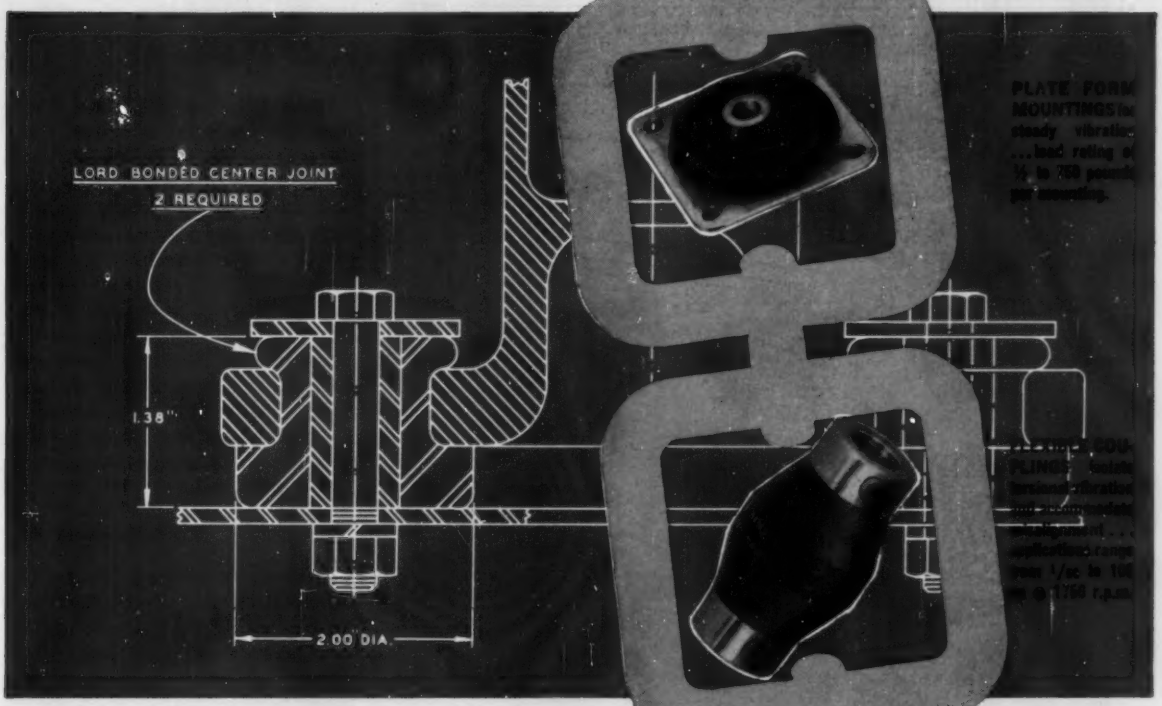
Processing

Induction Heater: Model L6E Reevelec 2-kw induction heater is used for soldering, brazing, hardening, annealing and other production operations. The bench-mounted unit has a built-in output transformer for matching a variety of load shapes and sizes; built-in automatic recycling heat cycle timer with wide choice of ranges; circuit breaker protection of both line and high voltage circuits; outlet for interconnection of remote switches, turntables or other fixture interlocks; watercooled coil and transformer circuits, and a forced air cooling system for the entire unit. The heater weighs approximately 200 lb and measures 28 in. high, 25 in. wide and 18 in. deep. It is equipped with protective interlock switches on all access doors and has grounded low voltage output circuits. Heater complies with FCC regulations. *Reeve Electronics Inc., Chicago.*

Metal Spray Unit: Model C-2 Spraywelder is designed for use in applying hard-facing powders to most types of steel, cast iron and copper parts. Powdered alloys are first applied to the part by spraying and then are fusion-bonded by heating with an oxyacetylene flame. Metal spraying operations using aluminum, zinc, copper, nickel, stainless steel, brass, lead or high-temperature brazing alloys in powder form can also be handled readily by the unit. Components are mounted on a panel that can be wall or pedestal mounted. Complete unit includes a lightweight aluminum pistol, chromium-plated hopper, carburetor, combination air

LORD CONTROLS VIBRATION...ANYWHERE!

THE MOST POSITIVE BOND OF PRODUCT TO PERFORMANCE



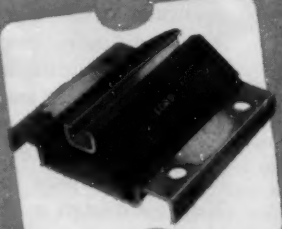
Vibration control is a vital element of improved product performance . . . and the most positive way to control vibration is through LORD Bonded-Rubber Mountings. Here are several outstanding reasons why:

Isolate Vibration — Stop noise transmission or vibration caused by moving mechanical components.

Lengthen Product Life — minimize stresses caused by shaft misalignment or torsional vibration.

Reduce Maintenance Expense — the rubber element absorbs flexing action . . . no surfaces to wear or chafe . . . no lubrication is needed.

LORD maintains a staff of vibration engineers to assist manufacturers in isolating destructive vibration. They will gladly assist you by designing and producing the most economical and efficient mounting for your needs. Call or write the LORD Mfg. Co., Erie, Pa.



CHAN-L-MOUNTS provide excellent reduction of steady vibrations and occasional shock problems. Designed to provide maximum deflection for their size.

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LOW NOISE LEVEL BRUSHES BY SUPERIOR

More and more, Industry is calling upon a Superior willingness to study a specific situation and come up with an answer that will make possible optimum brush performance.
More and more, Superior Carbon Brushes are doing a real job where noise level is an important factor.
More and more, a specialized Superior 37-year background is finding satisfactory solutions to these problems.
May we design a low noise level brush to meet your exacting requirements?

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"Since 1919"

New Machines

regulator-filter, and oxygen, acetylene and powder hoses and fittings. Redesigned carburetor and new spraying-head design contribute to high metal-spraying capacity and greater deposit efficiency. New filter includes a clear view plastic bowl which permits visual inspection for accumulation of moisture, dirt and oil. *Wall Colmonoy Corp., Detroit.*

Blast Cleaning Machine: Super Tumblast airless abrasive blast cleaning machine for cleaning sand, scale, oxides and other contaminants from metals is now available with operating load capacity of 14 cu ft. Abrasive-hurling wheel throws 830 lb of abrasive per minute. The unit is equipped with either of two separators, one for exacting requirements and the other for less exacting requirements. Separator is mounted at the bottom of the machine for easy servicing. *Wheelabrator Corp., Mishawaka, Ind.*

Testing and Inspection

Internal Measuring Unit: N-7 Internalchek is a heavy-duty shop and laboratory instrument for inspecting internal diameters of ring gages and other parts for size, taper, bellmouth and out-of- roundness. Standard capacity is from 0.370 to 12 in. with vertical capacity to 1½ in. Special gaging arms are available to provide gaging range from 0.240 to 12 in. with vertical capacity to 1 in. Instrument is available with dual electronic amplification of either 1000/2000, 2500/5000, 5000/10,000 to 1. Amplifications within each dual range can be switched from one to the other without realignment of indicating meter mechanism. With 5000/10,000 amplification, direct reading to 0.000010 can be made on the graduated 4-in. zero center equilinear scale. Both bench and floor-type models are available. Amplifier has a highly stable electronic circuit which is unaffected by line voltage fluctuations from 65 to 150 v. Indicator response is instantaneous and readings are consistently repetitive. Power requirement is 110 v, 60 cycle, ac. *Sheffield Corp., Dayton, O.*

NEW, COMPACT Century 48-FRAME Fractional HP MOTORS

INDUSTRIAL QUALITY for all applications

take less space...
weigh less...
perform better!

ROTOR

Rotor bars, end rings, and fans integrally pressure-cast of virgin aluminum. Rotors dynamically balanced to very close limits; meet strict quiet-motor requirements.

INSULATION

Heavy vinyl acetal insulated wire, tough mechanically, thermally, and dielectrically, has excellent moisture resistance, highest uniformity. Stator core slots lined with cells of DuPont Mylar bonded to all-rag electrical paper.

BEARINGS

Sleeve: pressed into place in bracket which has been bored true in single set-up operation. Finish boring operation assures proper bearing surface and concentricity. *Ball:* single-shielded, precision fitted in brackets.

LUBRICATION

Sleeve bearing type: wool yarn wicking provides constant oil supply to oil groove. Inner sump cup retains excess oil which is tapped by felt wicks extending into the wool yarn. *Ball bearing type:* standard construction permits re-greasing.

GOVERNOR and SWITCH

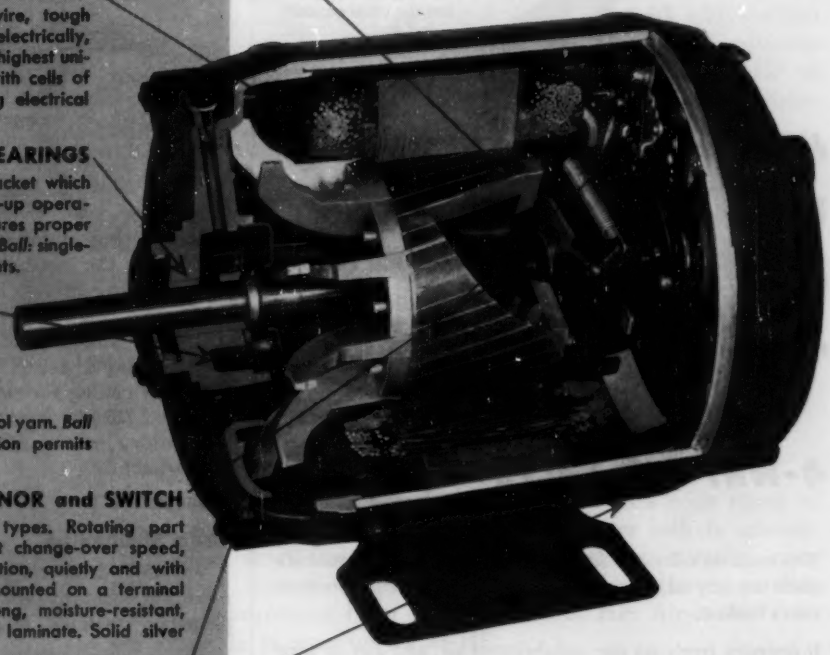
For capacitor and split phase types. Rotating part securely press-fitted to shaft. At change-over speed, governor operates with snap action, quietly and with no flutter. Stationary switch is mounted on a terminal plate; plate is GLASTIC, a strong, moisture-resistant, arc-resistant glass-filled polyester laminate. Solid silver contacts are used.

BEARING BRACKETS

Pressure cast in special aluminum casting alloy. Stress relieved for permanent stability. Strong internal ribbing for strength, and smooth outside surface.

FRAME

Stator frame rings formed of one-piece heavy rolled steel. No frame openings; windings fully protected. Rabbet fit faced and bored true to provide proper alignment of bracket and a concentric air gap. Heavy formed steel feet welded to frame ring.



Century Industrial Quality means *design* that does not compromise dependability to gain slight cost advantages... sturdy construction provides the stamina which assures continuous operation. 48-Frame Motors now available from 1/20 to 1/3 HP... Performance-Rated to your needs... with weight savings up to one-third!

Test one of these motors for yourself. Call or write your nearby Century District Sales Office or Authorized Distributor. Send for new bulletin 1-1P1.

Performance-Rated© MOTORS
1/20 to 400 HP

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64

ARE YOU CHANGING DESIGN ON AIR OPERATED MACHINES TO CUT COST AND IMPROVE OPERATION?

*$18.50 is the list price for the ¼ inch port size and $19.50 for the ⅜ inch, less the usual quantity and trade discounts.

HERE'S BOTH LOWER COST AND BETTER CONTROL IN THE 'SHEAR-SEAL' 4-WAY AIR VALVE (250 P.S.I.)

You need no oiler and filter ahead of this valve because it's made entirely of corrosion resistant materials and moisture won't harm it.

It operates freely on dry, unlubricated air, and dirt or pipe scale in the line cannot damage the valve or hold it open because of the unique "Shear-Seal" design.

The leak-proof holding quality which does not diminish after prolonged service is perhaps the most outstanding characteristic of the wear-compensating "Shear-Seal."

The external design stresses savings through convenience of porting, any port can be the "in" port; of mounting, valve has a bracket that may be shifted or removed to make way for panel mounting; of maintenance, valve can be serviced without touching the plumbing.

Ask for bulletin A-5.

BARKSDALE VALVES

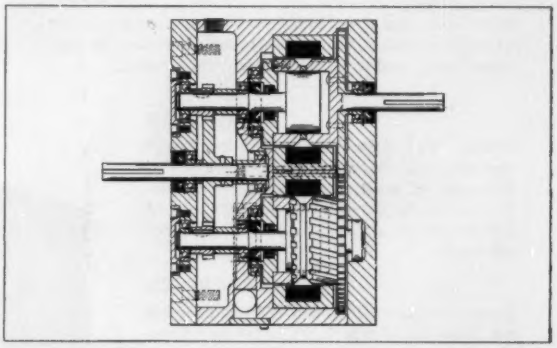
5125 Alcoa Avenue, Los Angeles 58, California

Circle 520 on page 19

NOTEWORTHY Patents

Reversible Drive Mechanism

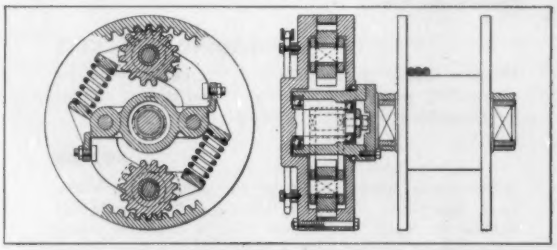
Nearly instantaneous reversal of output-shaft rotation is provided by a reversible drive mechanism that operates without physical movement of gears or wear



on contacting clutch elements. With unidirectional rotation of the input shaft (right), selective energization of either of two magnetic-particle fluid clutches determines the torque path through the unit and, therefore, direction of rotation of the output shaft (left). Rapid action of the self-contained clutches reduces time lag for reversal to an insignificant value. *Patent 2,752,800 assigned to Raymond Engineering Laboratory Inc. by Horace H. Raymond and Howard H. Sargent Jr.*

Drag Mechanism

Variable drag torque, such as that required to maintain constant tension in cable reels of electrically propelled vehicles, is developed by a planetary-type



fluid-drag mechanism. Designed for mounting on a moving vehicle, the unit exerts high drag torque at low cable pay-out speeds, decreases drag torque as pay-out speeds increase. Drag action is due to oil trapped between planet and ring-gear tooth spaces. At high vehicle speeds, the ring gear, which is attached to the unit housing, rotates rapidly and forces the spring-loaded planet gears partially out of mesh. Since oil in tooth spaces can escape, the planet car-

EATON

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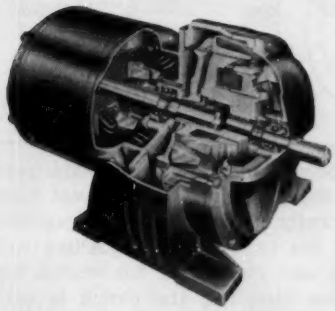
EDDY-CURRENT EQUIPMEMT

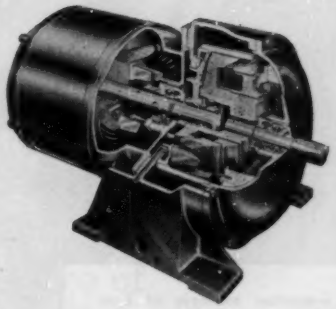
The Most Accurate and Trouble-Free Method of Adjustable Speed Control and Testing—at Minimum Cost



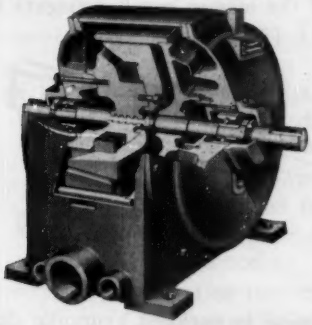
Ajusto-Spede® Drives

Dynamatic Ajusto-Spede® Drives supply infinitely adjustable speed from an AC power source—with low power losses and minimum maintenance. These air-cooled, stationary field, eddy-current couplings, integrally mounted with standard D-flange AC induction motors, provide a complete package-drive in sizes from 3 HP to 75 HP. Units of the same design and capacities are also available without motors.

Dynaspede® Drives

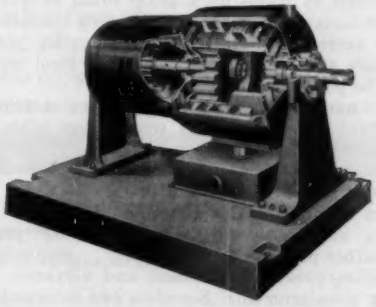


These Dynamatic liquid-cooled, adjustable speed, Eddy-Current Couplings, integrally mounted with standard D-flange AC induction motors provide a compact self-contained drive in sizes from 3 HP to 75 HP. Motor types available are drip proof, totally enclosed fan cooled, and explosion proof. The coupling is completely enclosed. Separately mounted couplings are also available in capacities from 3 to 2500 HP and larger.



Eddy-Current Brakes

Dynamatic Eddy-Current Brakes are available in a wide range of torque capacities and operating speeds. Features include smooth, frictionless, shock-free operation with no rotating electrical components or contacts. Liquid-cooled types, as illustrated, provide loading requirements from 40 HP to 10,000 HP. Air-cooled units are available in sizes up to 50 HP.

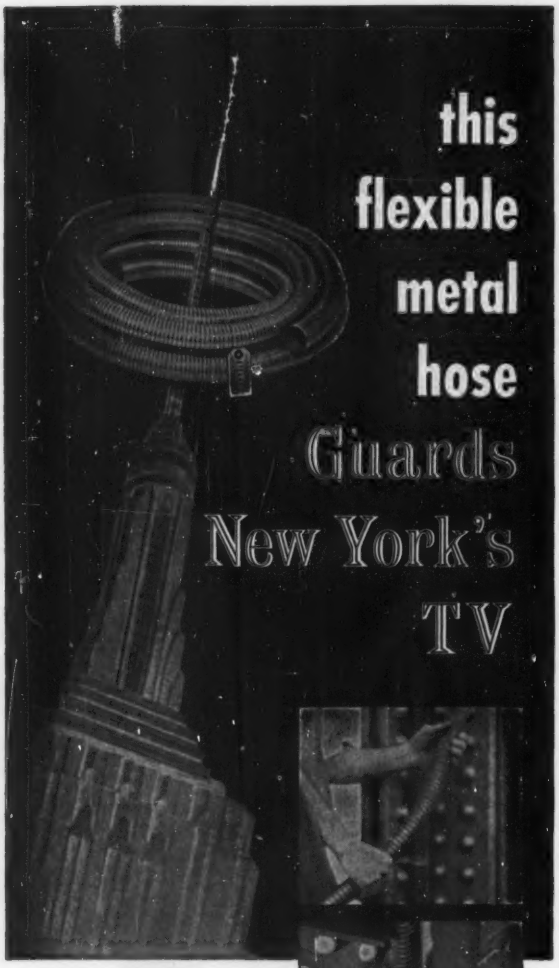


Dynamometers

Three types of Dynamatic Eddy-Current Dynamometers are available to meet various testing requirements; absorption dynamometers up to 15,000 HP; motoring or driving dynamometers up to 500 HP; and universal dynamometers to 500 HP and larger. Special purpose dynamometers are also designed for use in applications where requirements are unusual.

Send for Illustrated Literature Covering these Dynamatic Units

EATON MANUFACTURING COMPANY
DYNAMATIC DIVISION
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN



—another example of how Atlantic's engineers and ingenuity devise new solutions to new problems.

The $1,000,000 tower atop the Empire State building was designed to usher in a new era in TV transmission and reception. Its construction required an unprecedented number of circuits to travel up a tower often of less than two feet square. The conduit, enclosing the cables, had to be extremely *flexible* to avoid splice plates, rivet heads and diagonal braces in the steel work. It had to be permanently weather tight.

Ordinary rigid and flexible metal conduit failed! Atlantic's engineers in cooperation with the RCA Service Co. designed a heavy duty, high pressure bronze hose that did the job and also saved many costly and hazardous man hours of work. This hose was JOB TESTED and CERTIFIED.

Our engineers will help solve *your* problems in weather protection . . . flexibility . . . conveying . . . controlling pressure, movement and vibration . . . correcting misalignments. Seamless and Interlocking Hose. Bronze, Steel, Stainless Steel, Monel. ⅛"-36" I.D. with proper fittings. Write for Bulletin #500A See our Catalog in Sweet's Product Design File.

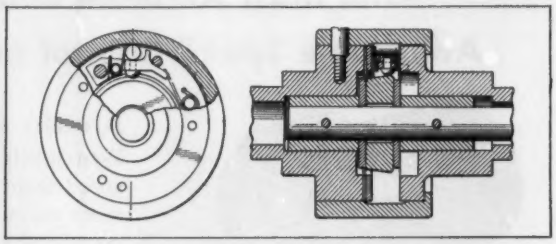
ATLANTIC METAL HOSE CO., Inc.
318 DYCKMAN STREET, NEW YORK 34, N.Y.

Noteworthy Patents

rier, which is coupled to the cable reel, can rotate freely and drag torque is low. At low vehicle speeds, the opposite action occurs. *Patent* 2,764,903 *assigned to Goodman Mfg. Co. by Frederick B. Miller.*

One-Way Clutch

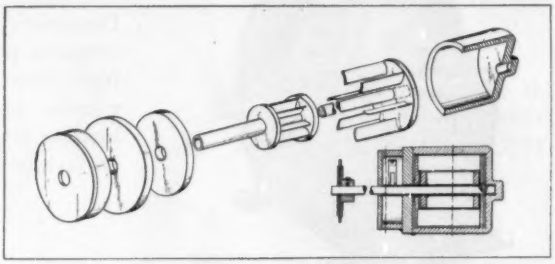
Coaxial input and output members (left and right) are coupled by the wedging action of multiple rollers in a one-way clutch. Engagement occurs when roller-



carrier levers are pivoted outward by the axial movement of a tapered engaging ring. In the event rollers are not symmetrically positioned at engagement, floating action of the tapered ring equalizes roller wedging pressures and distributes the clutch load. Free-running in one direction, the clutch is easily adapted for single or fractional-revolution operation. *Patent* 2,754,947 *assigned to Chicago Nipple Mfg. Co. by George B. Marsden.*

Fluid-Actuated Governor

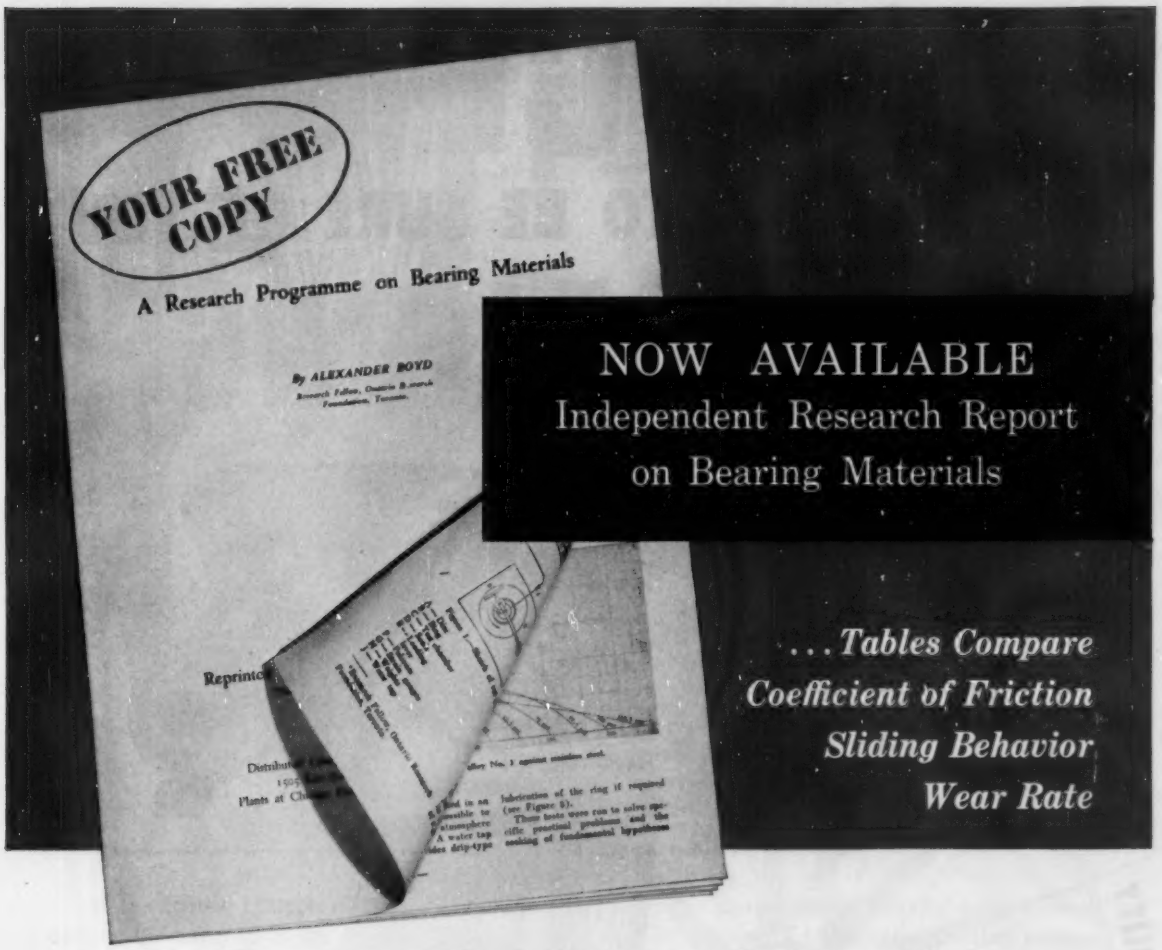
For speed control of electric, hydraulic or pneumatic motors, a fluid-actuated governor utilizes the turbine action of coaxial impellers as a speed-sensing means. Rotation of the master impeller (right) im-



parts a swirling motion to enclosed hydraulic fluid, forcing the slave impeller (left) to rotate. At a predetermined speed, torque developed by the slave member actuates an external spring-loaded switch assembly, providing governing action for the speed-controlled unit. Torque developed, and therefore the speed set-point, depends upon the viscosity and amount of fluid in the governor chamber. *Patent* 2,734,608 *assigned to Belle City Malleable Iron Co. by Joseph J. Longo.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

Circle 522 on page 19



Two year study evaluates performance of more than 100 combinations of bearing materials

THE RESULTS of this study are of importance to every engineer interested in bearing problems ... and the relationship between frictional force, speed and the wear behavior of materials.

More than 100 combinations of currently used bearing materials were tested for sliding behavior, coefficient of friction and wear rate. Results of the tests are compiled in tabular form for easy reference.

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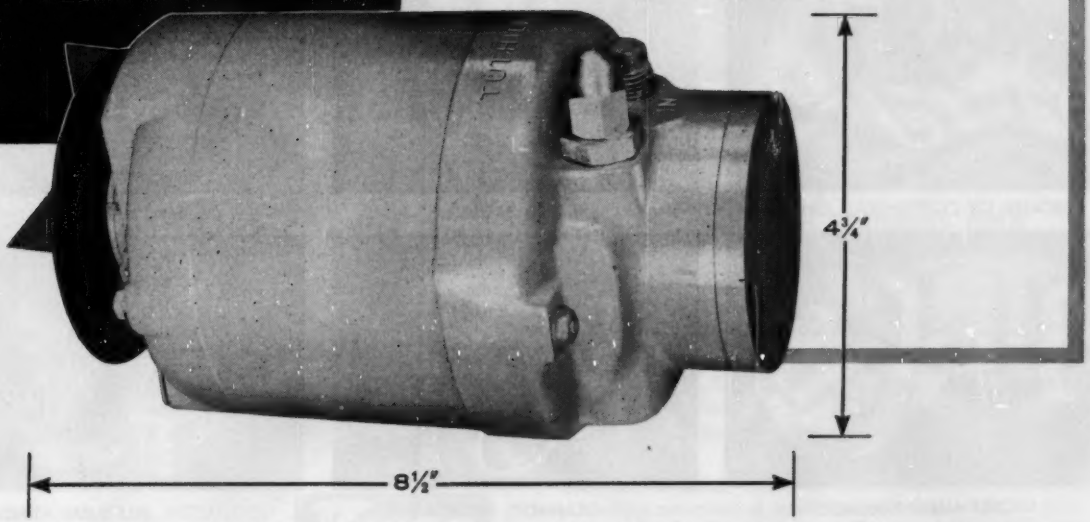
ANOTHER PUMP PROBLEM... SOLVED BY **TUTHILL**

new POWERMITE

PUMP and MOTOR COMBINATION

• COMPACT • LIGHTWEIGHT
• ECONOMICAL



Here's another example of Tuthill's ability to develop the pump to fit the problem. This compact, new Powermite motor-pump combination, a Tuthill exclusive, was developed to meet the requirements of original equipment manufacturers with unusual space and weight limitations.

Motor and cooling blower have, in effect, been incorporated into the internal gear positive displacement rotary pump. The whole unit takes up no more space than a standard electric motor. A single shaft serves all units of the Powermite—and the elimination of couplings, other parts and labor permit substantial economies for OEM applications.

The pump section contains a built-in strainer, and, if desired, an adjustable relief valve. Powermite can be furnished with cooling blower, as illustrated, or it may be supplied with a shaft extension for driving other accessories.

Powermite can be furnished in a wide variety of pump and motor combinations for use in hydraulic, oil burning, lubricating, and other services involving many different fluids. For example, the model illustrated has a capacity of 18 gallons per hour at 300 psi, and is driven by a 1/12 hp motor at a speed of 1750 rpm.

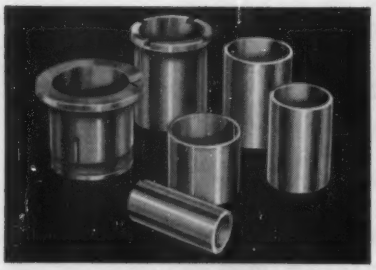
Manufacturers desiring to investigate the cost, space and weight saving advantages of incorporating Powermites into their products are invited to submit detailed specifications. Or, if preferred, a Tuthill representative will call.

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois
Gentlemen:
☐ Please have your representative call to discuss Powermite applications in my product
☐ Please send catalog describing complete Tuthill line.
NAME_____ COMPANY_____
TITLE_____
STREET_____
CITY_____ STATE_____

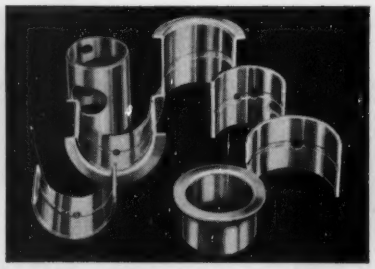
Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities from 1 to 200 GPM, for Pressures to 600 PSI, Speeds to 3600 RPM.

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois
Canadian Affiliate:
Ingersoll Machine & Tool Company, Ltd., Ingersoll, Ontario, Canada

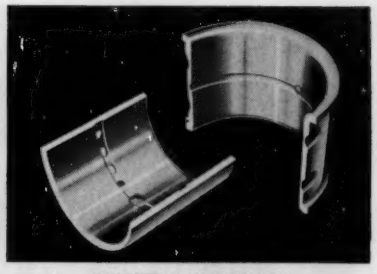
PUMPS FOR YOUR PURPOSE



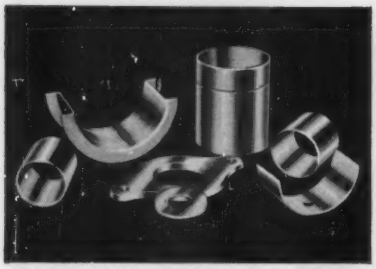
CAST BRONZE



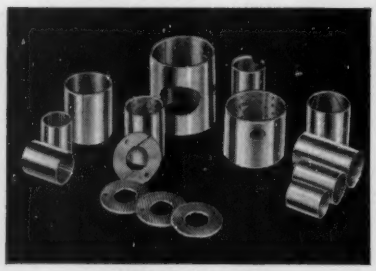
BABBITT AND STEEL



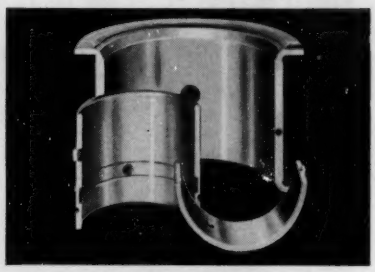
BABBITT AND BRONZE



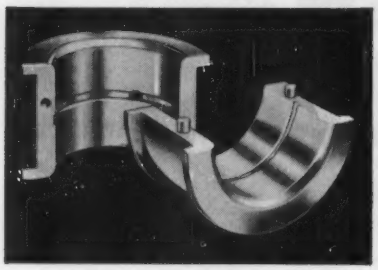
BRONZE OR COPPER-LEAD ON STEEL



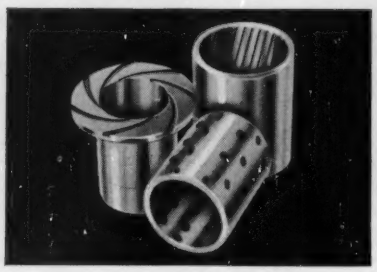
ROLLED BRONZE



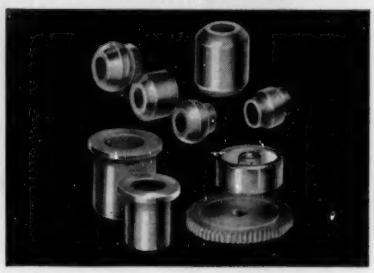
ALUMINUM ON STEEL



CAST ALUMINUM ALLOY



GRAPHITED BRONZE



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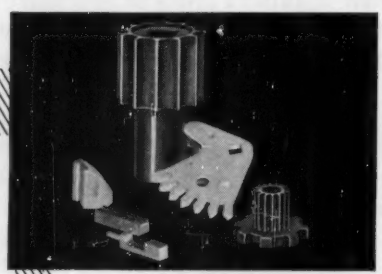

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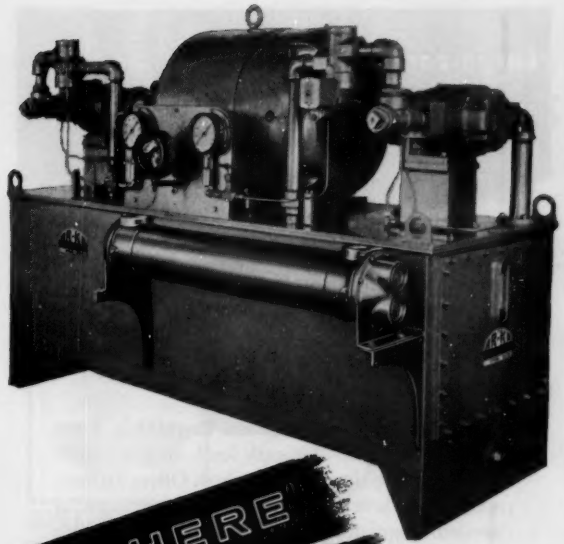
JOHNSON Bearings

Circle 526 on page 19



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Circle 527 on page 19

"Not one failure in 30 years," says Project Engineer, Walt Holms of Dexter Folder Company as . . .

Bristol's® Multiple-Spline socket screw solves 3 design problems here

On Dexter Folder Company's Cleveland folding machines, they didn't start out using Bristol's® Multiple-Spline socket screws.

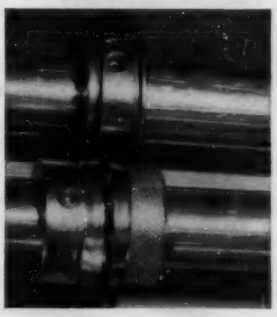
The switch to multiple-spline socket screws was made later on to overcome three difficulties caused by ordinary set screws:

1. Rounding out of sockets was common until the changeover to the multiple-spline screw. *"These Bristol screws are set and loosened as many as 1000 times during the machine's life, yet I never heard of a Bristol multiple-spline socket rounding out,"* reports Mr. Holms.

2. "Burrs" on the shafts, caused by the original steel set screws, were blocking movement of attachments along the shaft. To overcome this difficulty, Bristol engineers developed a new set screw design featuring a relatively soft brass point which could not harm the steel shaft.

3. Permanently mounted equipment, gears, pulleys and the like, used to freeze on the shaft after being in place for 5 or 10 years. The old set screws would frequently strip before loosening. Not one socket failure in 30 years has been noted since Dexter switched to Bristol's multiple-spline socket.

With 20,000 existing folding machines in operation and over 100 Bristol multiple-spline set screws in each, Dexter Folder Company's report on their performance carries considerable weight. Bristol's socket screw products—the most complete line on the market—are sold through leading industrial distributors. Find out about them today.



Bristol set screws hold perforator and grooved-wheel in tight alignment. Slippage here would damage knife blades. A.6.19

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Made in sizes as small as No. 0 in Alloy Steel and Stainless Steel. Cap Screws up to 1½".

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Circle 528 on page 19

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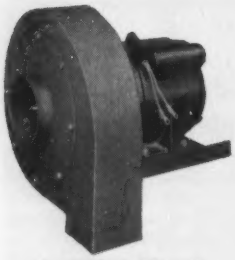

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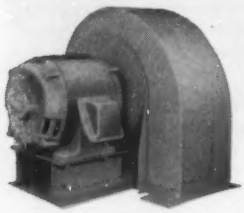

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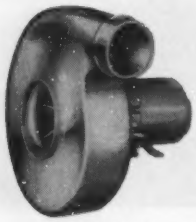

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Capacity 80 c.f.m.

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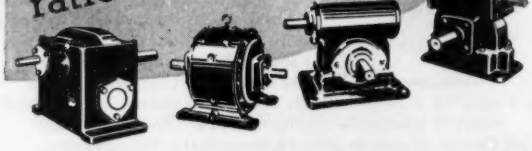

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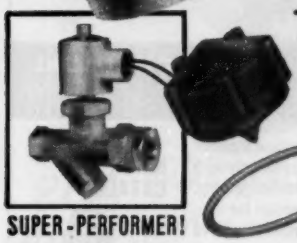

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Circle 532 on page 19

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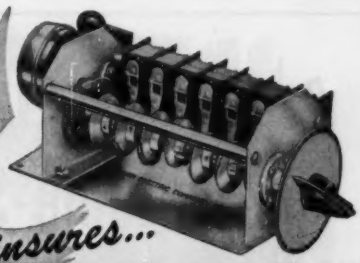

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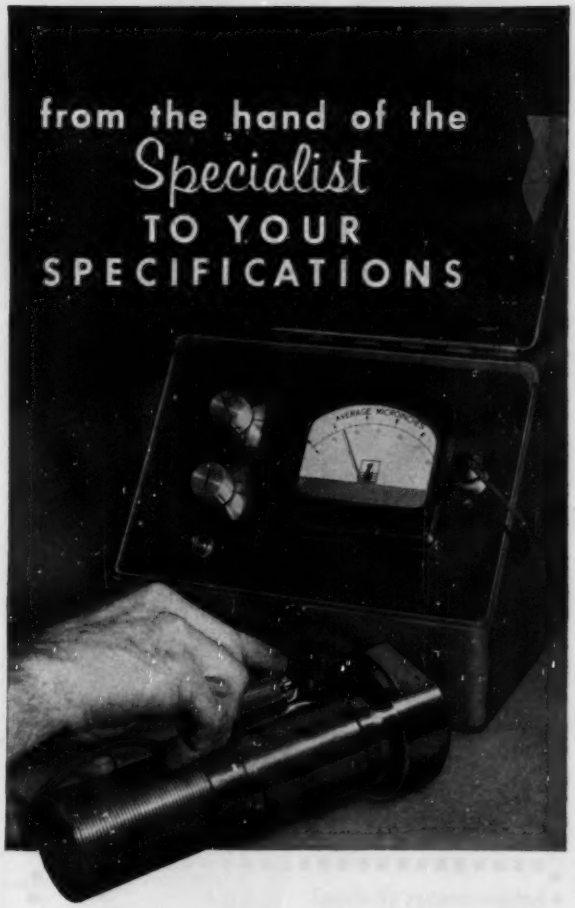

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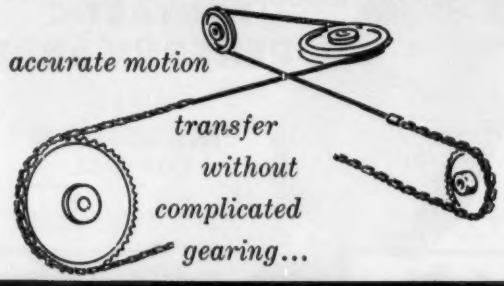

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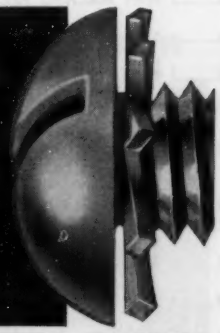

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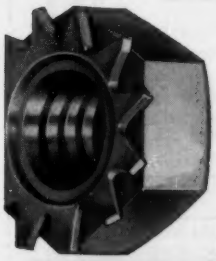

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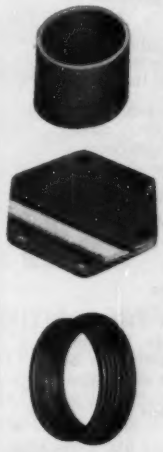

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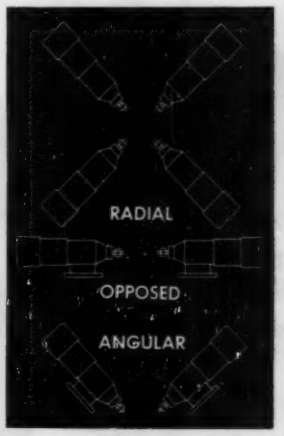

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Circle 541 on page 19

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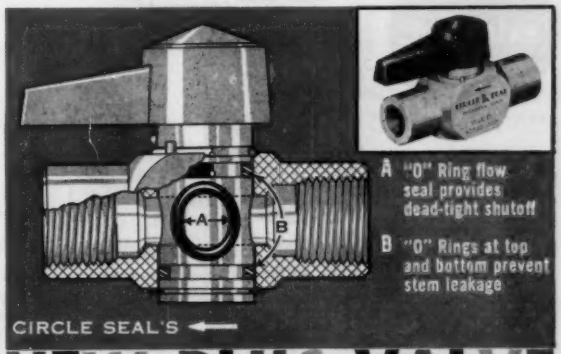

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Circle 543 on page 19

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new answer:

minnesota rubber's money-saving new

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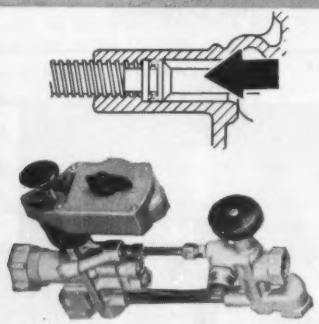

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Circle 544 on page 19

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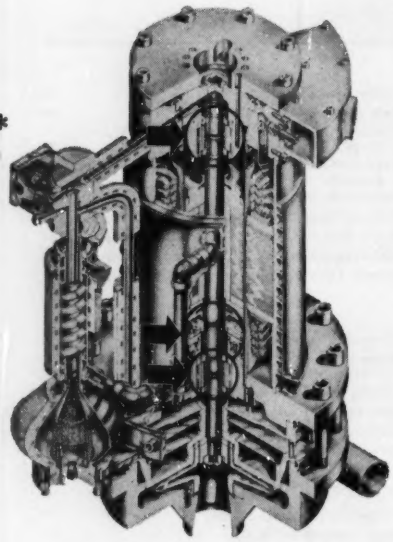
BPA NBP

Both KENNAMETAL* and KENTANIUM* in Westinghouse liquid metal pump



Cut-away view of Westinghouse pump to handle liquid sodium, NaK or other metals at temperatures up to 1500°F. Circles show bearings and thrust runners of Kennametal and Kentanium, which meet the most rigid specifications of tolerances and quality of material to provide *continuous, 100% leak-proof pumping operation for extended periods.*

Bearings and thrust runners operate perfectly after 2000 hours handling sodium, NaK and other metals at 1050°F and above

Kennametal and Kentanium are sharing in one of the engineering advancements of the year . . . the Westinghouse centrifugal liquid metal pump designed for the atomic power industry. Kennametal grade K9** and Kentanium K138A** were selected for the vital bearing and thrust runner parts which are lubricated by liquid metal with a film much thinner than oil lubricants. Surfaces must not corrode and must be highly wear resistant to maintain leak-proof seals . . . rugged requirements which Kennametal and Kentanium have met under gruelling tests.

RUGGED ENDURANCE TEST: After 500 hours of operation with the pump stream at 1050°F (and 120 psi head), the pump was taken down and the Kennametal and Kentanium parts examined. They showed no change. Now, after 2000 hours of around-the-clock operation, these parts continue operation in apparent perfect condition. Larger Westinghouse pumps now being built to handle sodium and NaK at 4000 gpm and 1500°F at 250 psi pump head include similar parts of Kennametal and Kentanium.

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*Trademarks of a series of sintered tungsten and titanium carbides.

**Approved, Bureau of Ships Specification, Carbide Stocks for Bearings, MIL-C-18482, 20/4/55.

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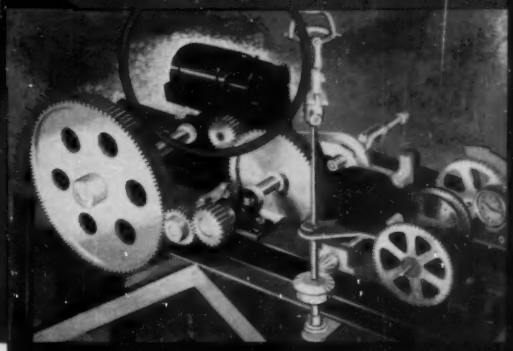

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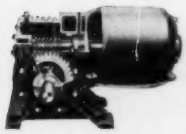

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Circle 402 on page 19

New design cuts setup time— TIMKEN® bearings up precision

BECAUSE it has no cams to change, this Warner & Swasey 2AC Single Spindle Chucking Automatic sets up fast like a turret lathe, gives you automatic operation without the usual time-consuming setup procedures.

And among the many design features contributing to the lasting production accuracy of the 2AC is the mounting of the spindle on Timken® tapered roller bearings.

Because of their tapered design, Timken bearings take radial and thrust loads in any combination, hold the spindle in rigid alignment.

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Timken bearings also save power because they practically eliminate friction. They are geometrically designed to give true rolling motion, precision manufactured to live up to their design. And to be sure we get steel good enough for Timken bearings, we make our *own* fine alloy steel. We're America's only bearing manufacturer that does.

No other bearings give you all the advantages that Timken bearings give you. That's why so many manufacturers of equipment that *must* have dependable bearing performance use them. Whether you buy or build machinery, be sure to specify Timken bearings. Look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable: "TIMROSCO".

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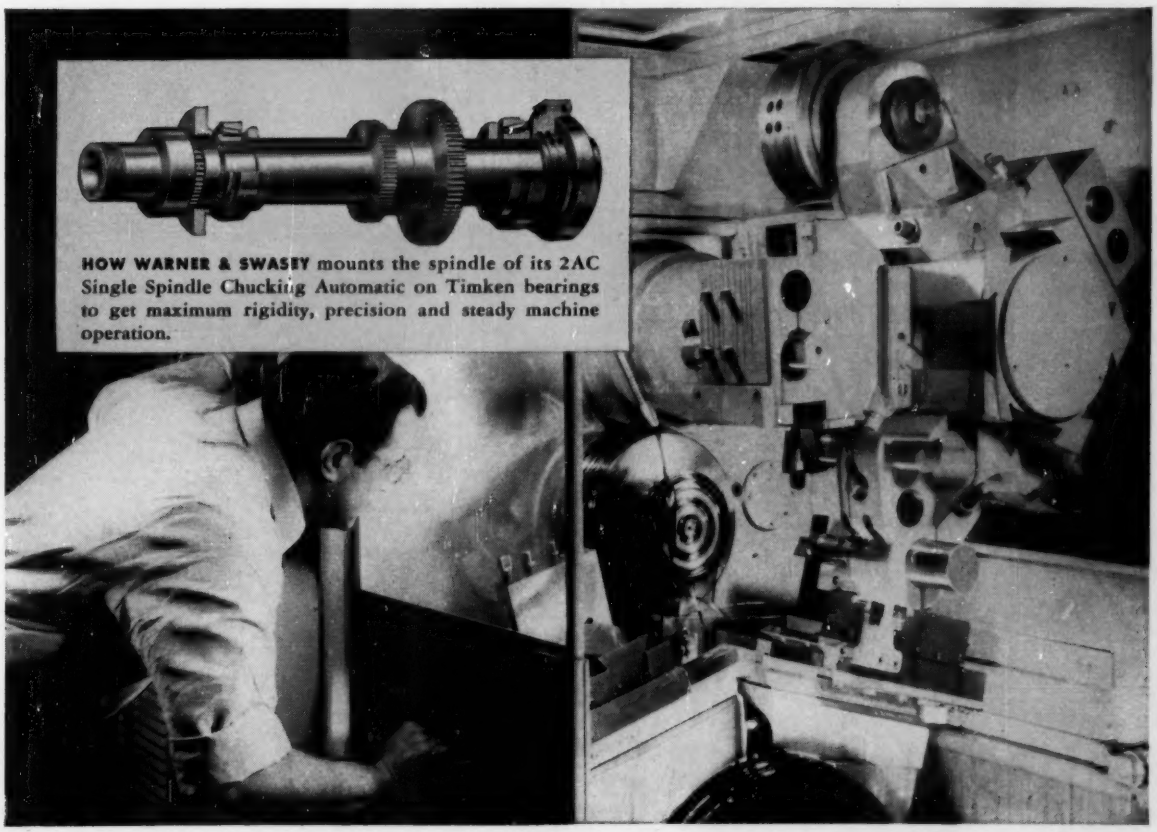
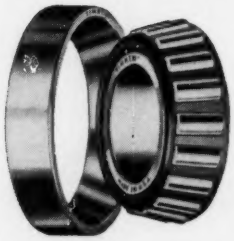


HOW WARNER & SWASEY mounts the spindle of its 2AC Single Spindle Chucking Automatic on Timken bearings to get maximum rigidity, precision and steady machine operation.



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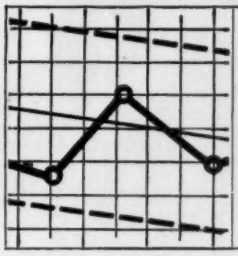

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Circle 403 on page 19